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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND B. ALFRED RAWORTH.

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THE CASE FOR MACHINERY ON RAILWAY CONSTRUCTION IN CHINA.

By Harold Stringer, B.A., Assoc. M. Inst. C.E.

For a discussion of this question a description of the conditions obtaining on railway construction in China is perhaps not unnecessary. Here we have the transport problem in the most acute form, for China's roads are unmetalled and never repaired, with the consequence that a few hours' rain renders them impassable for days at a time, except for the very lightest traffic. They are purely fine-weather roads, and except in the north, where the climate is more settled, there cannot be said to be any real dry season. Even in the North the working season, owing to the winter, is confined to the months from March to November, which includes the very heavy rains of June and more particularly July and August, when damage to temporary works is certain to take place, and work is stopped for days at a time owing to the refusal of the men to work in the wet. Further, the carts of the country are not built for the carriage of heavy weights, and carts and cart roads are not universal, disappearing altogether south of the Yangtze River and giving place to tracks for mule and wheel-barrow transport. In addition, as every acre of ground is under cultivation and as cheap timber for corduroying soft roads is not to be had, the making of roads for transport purposes is not to be thought of.

The labour problem in China is non-existent. There is a plentiful supply of so-called skilled and unskilled labour. Labour generally is highly intelligent, the men are not given to drinking or striking, but they are conservative of old methods, and lazy if there is a chance. White supervision is confined to engineers, the white foreman or sub-contractor being unknown. Of the skilled labourers the mason is the worst; his work is very showy, but he prefers small stones, badly bedded and packed with spalls, and he never improves. The carpenters are not good as a whole, but they are good enough for ordinary railway work. Fitters and blacksmiths are mediocre. The following are the average daily wages of various classes of labour in the North; in South China wages are slightly higher*:—Coolie, 23 cents, or 4.6d.; carpenter, 30 cents, or 6d.; bricklayer and mason, 30 cents, or 6d.; fitter, 50 cents, or 10d.; blacksmith gang, smith and 2 strikers, 1.24 dols., or 24.8d.

Turning to the question of supplies, good cement, lime, and bricks of poor quality are always obtainable; timber, steel, and steel tools have to be imported. There is one steel works in the country, at Hanyang, near Hankow, which rolls rails; but the output is uncertain and cannot cope with the requirements.

The last condition, which is perhaps peculiar to China, is the fact that it is a country of many rivers, liable to quick flooding and change of course in many cases; as a consequence the amount spent on bridge building is always heavy. There are therefore many instances in which time and labour-saving machinery might possibly have effected a saving; at any rate, such instances are very likely to occur. It should be said here that the standard of railway construction is high, as shown by the demand for a maximum grade of 1 in 100 and minimum curves of 1000 ft. radius. All lines are fully ballasted. Express trains run up to 50 miles an hour.

With conditions as above it is obvious that every effort should be made to eliminate road transport and everything subordinated to pushing the rails through as quickly as possible. This implies that practically all the earthwork will be completed ahead of rails, that deviations will be put in wherever possible for the bigger bridges, and temporary bridges of sleeper stacks and rails used for the smaller openings. This is the universal and necessary programme, and it necessarily eliminates the steam navvy on railway work. Even if the above-named conditions did not compel this, the great preponderance of bank on the great plains of China would prohibit its use. The transport conditions effectually forbid all thought of the use of machinery ahead of rails. Also the large number of sleeper stack bridges of height less than 20 feet implies that much of the pile-driving must be done ahead of rails. This involves the sinking of some capital in the construction of hand pile-drivers, and makes it doubtful whether a steam pile-driver would pay for itself. Pile-driving is a big item in China owing to the liability of most rivers to scour.

Plant Charges.—Before going further into the subject, it would be as well to state that it is proposed to charge off the cost of all plant to the jobs engaged on. This is done for the following reasons: firstly, because there is little or no market for special machinery when done with; secondly, the amount of plant which can be permanently utilised on maintenance work is very small. For instance, a steam-crane is always useful in breakdowns, and by removing the jib is easily converted into a very portable steam-winch and from that into a steam pile-driver by fixing a snatch-block to the base of the ordinary hand machine. Portable boilers and pumps can also generally be utilised in the provision of water supply to engines and staff, and portable engines in the various fitters' and other shops attached to the headquarters of divisional engineers. But the rest of the plant goes into store, where it undergoes rapid deterioration, mainly owing to the severities of the climate, but a good deal by neglect, and by the theft of every easily removable part, for no piece of scrap comes amiss to the Chinaman, and brass is almost a precious metal to him. It should be mentioned here that all rubber perishes very rapidly, and that pumps with rubber parts are to be avoided; also that all portable boilers should be provided with a feed-pump as well as injector, mainly as a stand-by. The last reason for charging off all plant is that the estimation of repairs is a difficult job, owing to the varying conditions—*e.g.*, the presence or otherwise of bad water.

Excavating Machinery.—All earthwork in China is done by Chinese contractors, who thoroughly understand their business and require little or no white supervision. Banks are built from borrow-pits and cuttings are run to spoil, baskets and shovels being the only tools employed. As a rule, there is no fault to find with the organisation of the work, and all that the foreign engineer has to insist on is that places liable to flood are rushed up when there is a chance, for flooded borrow-pits mean either extra land, train-hauled material, or pumping, at any rate extra expense.

As previously stated, excavating machinery is out of the question as far as railway work is concerned, but it is doubtful if it could be made to pay even in the case where the transport factor is absent, as on a dock contract. Such a job carried out in the usual way would be done by coolies loading into trains, probably about 2000 coolies on a 1,000,000-cubic-yard job. An engine and wagons would be required in both cases, and similar plant for dealing with the water, so that the only extra plant required would be the steam navvy itself. It is estimated that the cost of a 10-horse-power Ruston Proctor steam navvy would amount, delivered in China, to about 1320*l.* The work done in the ordinary way by coolies loading into 30-ton cars would cost about 50 cents, or 10d, per fang of 100 cub. ft. The maximum average output is taken to be 800 cubic yards per day of 10 hours for the steam navvy. The following is an estimate of the staff required to run the machine:—

	Dols.
1 navvy-driver	1.00
3 stokers	0.90
1 bucket-man	0.30
4 water coolies	1.00
2 cleaners and fitters	1.00
1 ton of coal	7.00
Oil and waste	1.00
Total daily cost	12.20

Incidental work round tip, &c.

2 foremen	0.80
1 loco driver	1.00
2 firemen	0.60
1 roperunner	0.30
2 cleaners	0.60
16 wagon-tippers	4.00
12 platelayers	3.00
4 coolies	1.00
4 horse-drivers	2.00
Total daily cost of working	25.50 (or 2*l.* 2*s.* 6*d.*)

This is the cost of 800 cubic yards, or a cost per cubic yard of $\frac{1}{2}$ of a penny, or 11.8 cents per fang of 100 cub. ft.

On the basis of charging off the plant it would pay to bring in a steam navvy if plant charges were run up to the figure of 38.2 cents per 100 cub. ft., this being the difference in the cost of excavation by hand and that of steam excavation at 11.8 cents per 100 cub. ft. In other words, it would pay to introduce the steam navvy on a job containing 56,000 fang, or 208,000 cubic yards, if time were no object. This estimate is based on the assumption that no white supervision would be required. This would certainly be required at first, and probably all the time, for the economical handling of a steam navvy necessitates considerable training. Whether the Chinese could be trained to do such work is difficult to say, but, judging from their achievements in other directions, there should be little doubt about it. White supervision would double the daily cost, and would make it worth while to introduce two navvys on a 1,000,000-cubic-yard job. The work would take about five times as long as the coolie method, but would be about 8000*l.* cheaper, but the value of the 18 months' delay in starting the working of the dock might far outweigh this on an undertaking of large capital. In the above the staff is double that employed in England, and the coal consumption also doubled, on account of theft and inferior quality. In the coolie method it has been assumed that 100 cub. ft. per man per day would be shifted, and that about 2000 coolies would be employed. In the one case you have a known and certain thing; in the other an experiment, the cost of which may still have been under-estimated.

Pile-Driving Machinery.—As previously stated, a good deal of the pile-driving on railway work is necessarily done ahead of rails, and for this purpose the only possible machine is the hand one, on account of the transport problem. The standard type is the 26-ft., which is merely a strongly-strutted and braced A frame, with a hand winch, $\frac{3}{4}$-ton monkey and chain. Chain is used instead of wire rope, because a chain, if it does break, can be easily repaired in the nearest big village, where there is always a blacksmith; whereas a wire rope repair would have to be sent to the nearest shops, perhaps some days away. The pile-driver described can be taken to pieces and loaded into the ordinary country cart, and so presents no transport difficulties. The crew required for such a machine, and their daily wages, are as follow:—

	Dols.
1 foreman	0.40
10 coolies	2.50
1 carpenter	0.30
Total daily cost	3.20 (or 5*s.* 4*d.*)

The average daily performance of such an engine would be one pile driven 18 ft. To drive one pile the cost is thus 3.20 dols. (or 5*s.* 4*d.*). The pile driven is a 20-ft. pole, 10 in. diameter at the big end; for heavier piles the 40-ft. engine is employed. If steam drivers were used, about four piles could be driven, and with a jet to help, of course more. One instance is on record where the speed of driving was accelerated five times by the use of a jet.

By employing a steam winch and boiler coupled with the already existing hand pile engine, the purchase of the ordinary type of steam pile-driver, with its expensive monkey, could be avoided. In any case, the above combination is perhaps most suitable, as the boiler and winch can be fixed at a convenient distance from the pile engine, and the heavier staging and greater labour in shifting the usual form of machine avoided. Also by the use of a long length of wire rope coupled with a snatch-block secured to the base of the pile engine, a large number of piles can be driven without moving the boiler or winch. Wire rope is necessary owing to the braking effect of chain in the case, as here, where the monkey is dropped by pulling out the clutch on the winch and not by the use of trip gear. As pointed out above, there is always the possibility of helping matters by introducing a water jet, if the ground is suitable and water is available. The cost of boiler and winch delivered in China would be about 180*l.*, and the cost of a pump suitable for a jet

* Throughout this article dollar current has been valued at 1*s.* 8*d.*, or 5 cents to the penny, and the unit of volume adopted is the "fang" of 100 English cub. ft.

about 30*l*. The estimated daily cost of running such a pile-driver is as follows:—

	Dols.
1 engine-driver	1.00
1 fireman	0.30
2 water coolies (for feed water) ...	0.60
1 foreman	0.40
6 coolies	1.50
1 carpenter	0.30
1 ton of coal	7.00
Oil and waste	1.00
Total cost of driving 4 piles ...	12.10

or the cost per pile is 3.02 dols. (or 5s.). It would therefore pay to introduce a steam pile-driver if plant charges per pile driven were run up to the difference in driving costs by the two methods, which is 18 cents, or 4d. per pile. Then, in order to pay for itself, each steam machine must drive about 12,000 piles—an altogether impossible number for one machine, so that the steam machine cannot compete if plant is charged off. There is, however, the saving of time to be considered in the steam machine. Thus if it is assumed that the value of one day's delay in opening a section of line between potential traffic centres is the future net earnings per mile, multiplied by the distance between the above centres, the value of one day's delay on Chinese railways is about 3*l*. per mile, assuming the line to cost 10,000*l*. per mile, the interest on this at 5 per cent., and the gross earnings at twice the net.

This is, of course, an extreme view, as a construction programme is in most cases largely made with a view to supplies and weather; but it is easy to imagine a case where time-saving would be of tremendous value, in a country where the working season is limited, and where failure to complete an operation in one working season means delaying the opening of the line, not by days, but by the interval between working seasons; and more than this, for the organisation of the work has to be done twice. This is specially true of pile-driving, which is virtually impossible in the winter in the North, and where all work is shut down if possible. Another case where time-saving may be of great value is in perhaps avoiding the washouts which are unavoidable during construction while the rainy season is on; a saving of a few days may mean that construction need not be held up for a few weeks, besides saving the loss in repairing deviations and temporary bridges. It is, of course, impossible to put this into figures, but there is no doubt that all railway jobs of any size could afford to convert 3 or 4 pile engines into steam drivers on account of the after-utility of boilers and winches in well-sinking, wash-out work, quarry work, and bridge renewals. Whether more should be converted would depend on circumstances, no two cases being alike. It should be said here that the steam pile driver is, if anything, overstaffed, and that the coal consumption has been doubled on account of theft, &c. Another and very great advantage, not possessed by the hand machine, is its ability to keep heavy piles, such as used in the foundations of the 200-ft. spans, continuously on the move.

Stone Breaking and Quarrying Machinery.—It is the custom in China to break all stone by hand. The large number of bridges and the practice of fully ballasting all roadbeds as quickly as possible make the cost of ballast a very important item. Usually a quarry site is chosen wherever possible, and as close to the line as practicable, and a siding run in. A contract is then let to a Chinese contractor for quarrying, breaking and loading rubble, concrete ballast, and railway ballast. The contractor is bound to deliver a certain amount per month or be fined. The railway supplies no plant, but sells the man explosive, drill steel, and fuse at cost price. The prices usually paid for such work vary with the locality slightly, but the following are Mid-China prices:—

	Dols. per 100 cub. ft.
Rubble	1.40
Concrete ballast...	2.50
Track ballast	2.20

It is suggested that the following plant might effect some saving when rail transport is available:—

	£
2 stone-crushers, 12-in. by 7-in. jaws...	240
1 10-horse-power portable engine ...	250
15 tons freight at 2*l*.	30
Total cost	£520

The output of this plant would be, say, 100 tons of stone per day of 10 hours, or 2000 cub. ft.; taking stone at 112 lb. per cub. ft. The running costs would be as follows:—

	Dols.
1 driver	1.00
1 fireman	0.30
5 coolies	1.25
½ ton coal	3.50
Waste, &c.	0.50
Total cost of 2000 cub. ft. ...	6.50

The cost of crushing 100 cub. ft. to any size would therefore be 32 cents, or 6d. To this cost must be added the quarrying cost of 1.40 dols. per 100 cub. ft. Then the total cost of any sized ballast will be 1.72 dols., or 34.5d. per 100 cub. ft. Therefore, if concrete ballast be considered, it would pay to introduce a crusher if plant charges were run up to the difference in costs of the two methods, or 78 cents per 100 cub. ft. In this case, in view of the undoubted after-utility of the machine, and also in view of the fact that efficient supervision and proper housing will be possible, a plant charge of 20 per cent. of the cost to cover one year's repairs and depreciation would appear to be a fair estimate. That is to say, that it would pay to introduce crushers if each machine crushed 160,000 cub. ft. Now, with track ballast alone at (at least) 80,000 cub. ft. per mile, it can be seen that this is a very small fraction of the amount required, and, consequently, that crushers would undoubtedly pay, more especially as practically all ballasting is done after rails are available. Moreover, the introduction of crushers would guarantee a fixed supply instead of the very uncertain supply given by the average Chinese ballast contractor, and the quality of the ballast would be better.

It is also suggested that the Chinese might be induced to try steam rock-drills; at any rate, the experiment might be tried with little extra expense if rock-crushers were installed in a quarry. By this means much bigger holes would be obtained and the quarrying rendered more economical of explosives, for no Chinese will make sufficiently numerous or big enough holes, with the result that the full power of the charge is never obtained. The time ratios for the same work—hand and steam rock-drilling—are about six to one where white labour is employed, and at least double this for Chinese labour. This ratio would appear to be sufficiently high to warrant the introduction of an experimental rock-drill, more especially as the extra plant charge per drill would not exceed 50*l*. if the same boiler power as that used for the crushers is utilised. The difficulty is the absence of any reliable data giving the amount of drilling done per 100 cub. ft. of rock excavated under present methods; also the doubt whether the Chinese would use the drills even if provided with them.

Concrete Mixing Machinery.—It is customary to mix all concrete by hand. The concrete when mixed is loaded into baskets and dumped into the forms, where it is well rammed. The labour cost of such work, placing only, is about 5.00 dols, or 8s. 4d., per 100 cub. ft. It is suggested that a belt-driven concrete mixer mounted with its engine in a 30-ton truck might at least save money on the mixing, and perhaps time as well. In cases where there was a deviation a sleeper stack and rail bridge would be built right over the site of the piers and the mixer moved over each pier as required, shutes being used to deliver the concrete to the moulds. In cases where there was no deviation the main line itself would be used, a siding being provided off the bridge for passing trains. The estimated cost of the plant is as follows:—

	£
1 half cub. yard mixer	150
1 4-horse-power vertical boiler and engine	100
4 side-tip 1-cubic yard wagons and rails	40
Total cost plant	290

The running cost would be as follows:—

	Dols.
1 driver	1.00
1 fireman	0.30
15 coolies (feeding mixer, &c.) ...	3.75
30 coolies (erecting staging, &c.) ...	7.50
5 cwt. coal and stores	2.25
2 foremen superintending coolies ...	0.70
Total daily cost	15.50

This is the cost of placing 60 cubic yards, or the cost of placing 100 cub. ft. is 97 cents, or 19.4d. This amounts to a saving in labour per 100 cub. ft. of 4.03 dols. and plant charges can be run up to this figure without loss; that is, if each mixer placed 870 fang of 100 cub. ft. each it would have paid for itself. Now it is Chinese practice to leave the bulk of the concrete work until rail transport is available, so that there would appear to be some scope for the concrete-mixer. It is realised that in many cases the capacity of the concrete forms would limit the output of the machine, and that somewhat special training would be required at first to cope with the large output. On this account the petrol-driven mixer of about 6 cub. ft. hopper capacity, giving an output of about 50 cubic yards per day would, perhaps, be the more economical machine. The petrol consumption of such a machine would be about 2 gallons per day, and the running costs no more than for the steam plant. The cost of the machine would be about 200*l*. Of course a specially trained driver would be required, but such men are obtainable and the extra cost has been allowed for. An additional advantage of this type of mixer is its extreme portability and the fact of its being self-contained: in fact, with a plentiful supply of spares and a capable driver, there is no reason why it should not be used, even in advance of the rails, in order to get ahead with the bigger bridges. It should also be remembered that a mixer saves the cost of mixing-boards, shovels, and baskets, quite considerable items on a large job.

The great argument against the use of the mixer is the number of moulds required to keep it going. It is the custom to employ one mould at a bridge, or at most two. These are built of 12-in. by 3-in. planks, usually about 10 ft. high for each lift. This type of mould is very heavy, but an excellent concrete face is obtained. If a mixer is to be used at least four moulds would be required for each type of bridge. If 1½-in. planks were used for moulds, the extra cost of making moulds to cope with a mixer for four types of bridges would be about 70*l*. per mixer at present timber prices. This should be added to the capital cost of the machine, as the theft of timber is too high to expect to get any credit on moulds after they are finished with.

Minor Machines.—The first of these is the steam-driven circular saw. Timber is imported in logs chiefly 12 in. by 12 in., and 14 in. by 14 in. and planks 12 in. by 3 in. and 12 in. by 4 in. The logs are sawn by hand into the required scantlings. The cost of sawing by hand in China is about 6.00 dols. per 1000 sq. ft. sawn. A circular saw cuts about 3000 sq. ft. per day of 10 hours at a low estimate.

Plant required:—

	£
1 6-horse-power boiler and engine combined	150
1 circular saw bench 35-in. saw ...	50
Total cost of plant	200

The cost of running per day would be:—

	Dols.
1 driver	1.00
1 fireman	0.30
2 carpenters (feeding saw, &c.) ...	0.60
5 cwt. coal and stores	2.25
Total daily cost	4.15

This is the cost of sawing 3000 sq. ft., or 1000 sq. ft. costs 1.38 dols., or 27.6d. This is a saving of 4.62 dols. per 1000 sq. ft. sawn, or 8s. 8d. nearly. In this case a 20 per cent. plant charge would suffice, as the conditions worked under would be fairly good.

Brickmaking machines could be introduced with advantage, even if only hand presses, on account of the superior quality of the brick produced. The present brick is very porous, soft, and, as often as not, insufficiently burnt. Suitable clay is not common, but once established, there should always be a market for good bricks. There is also very little doubt that hand paint-spraying machines would pay, owing to their small initial cost, about 16*l*. per machine, the saving in paint and brushes, and the fact that they can do about 10 times the work of an ordinary painter. Also bridge-painting is a very heavy item, as no paint seems to last more than five years. At present the labour cost of such work is about 44 cents, or 8.8d. per 100

sq. ft. It is estimated that a machine might reduce this to 18 cents per 100 sq. ft.

The most heavy items in plant charges have now been discussed, and, while it is recognised that the above are merely estimates of machine performances in Chinese hands, they are at any rate estimates with a very large reserve margin. It should be said here that steam pile-driving somewhat on the lines suggested in this paper has been tried in North China and has proved a success, saving much time and being slightly cheaper than the old method, so that there would appear to be some case for, at any rate, experimental trial. China, of course, possesses the great advantage of cheap skilled labour, which makes the labour cost of running machinery very low. The white engine-driver is unknown on the Chinese railways, and the work turned out by the locomotive and wagon shops of the country is excellent in quality. The white supervision of these works is very small, and the only white men in the running departments are the loco-inspectors at the larger engine depôts. In the present article the wages of engine-drivers are, perhaps, taken rather high, and the price of coal undoubtedly so for North China, where the prices paid by the railways are as follow: Lump coal, 5.00 dols., or 8s. 4d. per ton; dust coal suitable for boilers, 2.50 dols., or 4s. 2d. per ton.

In this paper the cost has been taken at an average of 7.00 dols., or 11s. 8d. per ton, which is perhaps high for dust coal, even in South China, where coal is much dearer. Throughout the Mexican dollar, in use in the country, has been taken at 1s. 8d., or 5 cents, to the penny. The introduction of machinery would not involve an additional charge for repair shops, as these are built in any case and are not fully employed during construction.

In conclusion, it would appear that the introduction of machinery into any country depends mainly on the type of line to be built, whether a light line, with high grades and sharp curvature, or the reverse; in other words, on the amount of work. It also depends on the transport and roads available, the weather conditions and on the construction scheme which the labour supply controls. Lastly, it depends on the feasibility or otherwise of reducing the white supervising element to a minimum, and of making the utmost use of the cheap labour available. Thus, on a heavy line in a country such as tropical Africa, where labour is difficult to obtain, the case for machinery would appear to be worth investigation, even though nigger labour is cheap. In China heavy lines have been avoided, up to now, in such cases by high grades and sharp curvature, in the hope that later developments will pay for improvements, the possible traffic on such lines in sparsely populated countries only warranting the minimum of capital expenditure.

I wish to thank Mr. T. W. T. Tuckey, M. Inst. C.E. and Mr. D. P. Ricketts, M. Inst. C.E., the Engineers-in-Chief of the Tientsin-Pukow and Peking-Mukden Railways, for permission to make use of information gained while working on those railways, and also to acknowledge my indebtedness for criticism and advice to Messrs. E. H. Rigby, M. Inst. C.E., L. J. Newmarch, M. Inst. C.E., and W. O. Leitch, M. Inst. C.E., of the Peking–Mukden Line.

HIGH-POWERED LOCOMOTIVES FOR THE PENNSYLVANIA RAILROAD.

(Continued from page 99.)

In designing the three classes of locomotives—namely, the "K 4 S," the "L 1 S" and the "E 5 S" Classes—to which this article relates, a special effort was made to secure interchangeability of as many details as possible. In the case of the "K 4 S" and "L 1 S" types, with which we are first dealing, the boilers are identical in design and dimensions and are, in fact, interchangeable as a whole. Owing to their exceptional size, providing as they do a total heating surface of 5,766 sq. ft., and a grate area of 70 sq. ft., their design possesses many points of special interest.

We give this week, on Plate XIV, in Figs. 9 to 14, views which show clearly the general design, while Figs. 15 to 20, on Plate XV, further illustrate special features to which we shall refer in due course. The boiler, which is made for a working pressure of 205 lb. per square inch, is of the Belpaire type, with a sloping back end plate and sloping throat plate. The contour of the fire-box shell in cross-section is somewhat unusual, as will be seen from Figs. 12 and 14, Plate XIV. The boiler barrel is made in three rings, the largest being 7 ft. 5 in. in diameter outside for its whole length, while the two other rings taper, the diameter of the barrel at the smoke-box end being reduced to 6 ft. 6½ in. outside. As will be seen from Fig. 10, Plate XIV, the bottom of the barrel is kept horizontal, the whole effect of the taper being confined, as far as the vertical diameter is concerned, to the top line.

A special feature is the method of constructing the largest ring. This consists of two plates united by longitudinal joints at the level of the centre line of the boiler. The upper of the two plates forms not only half the ring, but is flanged so as to form the "hips" for the front end of the fire-box shell, while the lower plate is prolonged and flanged so as to also form the throat plate. The upper plate just referred to is shown in the flanging die by Fig. 19, Plate XV; while Fig. 20 shows the plate removed from the die and with the steam dome attached. Fig. 16 on the same Plate shows the largest ring built up with the fire-box shell, and gives a very clear idea of the feature with which we have been dealing.

In the case of the inside fire-box the throat plate and the lower part of the combustion chamber are also made in one piece, the arrangement being clearly shown by Fig. 18, Plate XV; while Figs. 15 and 17, on the same Plate, are internal views showing respectively the fire-box tube plate with the fire-box shell stays, and the interior of the fire-box.

The largest ring of the barrel is made of plates 1 in. thick, while in the case of the two tapered rings the thickness of the plates is $\frac{15}{16}$ in. The thickness of the smoke-box tube-plate is $\frac{1}{2}$ in. The fire-box shell plates are $\frac{3}{8}$ in. thick, the back end plate being stiffened by a liner, also $\frac{3}{8}$ in. thick, at the upper part, where the attachments for the longitudinal stays are fixed. These stays, as will be noticed, are carried forward over the full length of the fire-box and are connected to gusset brackets riveted to the first ring of the boiler barrel, as seen in Figs. 10 and 14, on Plate XIV. There are also longitudinal stays extending from the back plate of the fire-box casing to the sides, as shown dotted in Fig. 13, while the longitudinal stays for the smoke-box tube plate are shown in Fig. 10. The upper part of the fire-box casing is stayed transversely by two rows of stays with screwed ends and 1¼ in. in diameter between the screwed portions, arranged as shown in Figs. 10 and 14, on Plate XIV.

The inside fire-box is made of $\frac{3}{8}$-in. plates, except the tube plate, which is $\frac{1}{2}$ in. The sides and ends are stayed by $\frac{7}{8}$-in. iron screwed stays spaced at about 4-in. pitch. Each stay has a hole $\frac{3}{16}$ in. diameter and 1¼ in. deep drilled into its outer end. The connection between the fire-box and fire-box shell at the bottom is by a solid ring giving 5-in. water spaces at the sides. The steam dome, which is very shallow, owing to the restrictions of the loading gauge, is formed of a single plate flanged as shown in detail in Figs. 41 and 42, on page 149.

The rings of the barrel have triple-riveted longitudinal butt joints with inside and outside welts, the outside welt strips being 12¼ in., and the inside welts 1 ft. 8⅛ in. wide. Both inside and outside welts are $\frac{5}{8}$ in. thick. The rivets are 1¼ in. in diameter (diameter of rivet holes $1\frac{5}{16}$ in.), and are spaced at 12-in. pitch in the outer rows of each joint and at 6-in. pitch in the two inner rows. A detailed section of a longitudinal joint is given in Fig. 43, on page 149. The transverse joints are double-riveted lap joints, the laps being 5¼ in., and the distance between centres of the two rows of rivets being 2 in. The rivets are 1⅛ in. in diameter (diameter of holes $1\frac{7}{16}$ in.) and they are spaced so that there are 75 rivets in each row of the seam at the front end of the largest ring, 74 rivets in the seam joining the two tapered rings, and 72 rivets in the seam adjoining the smoke-box tube plate.

The boiler contains 236 tubes 2¼ in., and 40 tubes 5½ in. outside diameter and 19 ft. long between tube plates. The arrangement of the tubes is shown by the cross-section, Fig. 14, Plate XIV, and also by the reproductions of photographs, Figs. 15 and 18, on Plate XV. All the tubes are of steel. The fire-box is also traversed by four water tubes for supporting the firebrick arch. These are not shown in the views of the boiler on Plate XIV, but their arrangement is illustrated by the larger scale views, Figs. 38, 39 and 40, on page 149. It will be seen from these views that the arch tubes are curved laterally so as to give them some longitudinal elasticity and avoid strains on the connections.

In view of the exceptional size of the locomotive boilers with which we are dealing and the very heavy demands made upon them, it appears worth while to describe in detail the practice of the Pennsylvania Railroad Company as regards the fixing of the tubes in their boilers. In the case of the ordinary tubes 2¼ in. or less in diameter outside, the holes in the fire-box tube plates are made of the same diameter as the outside of the tubes, and the edges of the holes are rounded to a radius of $\frac{1}{16}$ in. For the smoke-box tube plate the holes are made $\frac{1}{16}$ in. larger than the outside diameter of the tubes and the sharp edges of the holes are removed.

At the fire-box ends of the tubes soft copper ferrules 0.075 in. thick are interposed between the tubes and the tube plate, the ends of the tubes being swaged down to give space for the ferrules. The ferrules have an outside diameter equal to that of the holes and a length $\frac{1}{32}$ in. greater than the thickness of the tube plate. The ferrules are placed in the holes in the position shown in Fig. 21, page 148, and are rolled tight, using a tool known as No. 1. Next the tubes are placed in position as shown in Fig. 22, the swaged down end projecting $\frac{3}{16}$ in. on the fire-box side of the plate. When thus arranged the tubes are tightened by the use of Tool No. 2.

At the smoke-box end the position of the tubes will then be as shown in Fig. 23, the tube ends projecting not less than $\frac{1}{4}$ in. and not more than $\frac{3}{8}$ in. on the outer side of the tube plate. Fig. 23 shows the tool (No. 8) used at this stage of the operations. To complete the fixing at the smoke-box end the tubes are rolled with tool No. 1, as shown in Fig. 24, but this operation (No. 4) may, if more convenient, be deferred until after the completion of the fixing at the fire-box end.

Returning to the fire-box end, the next operation is that shown by Fig. 25, the ends of the tubes being opened by the tool No. 3 there shown, using a hand or pneumatic hammer. Next the tubes are expanded by the aid of a tool, No. 4, which produces an annular ridge on the tube just inside the tube plate, the copper ferrule being squeezed between this collar and the edge of the hole in the plate, as shown in Fig. 26. In carrying out this operation the tubes on the lines of holes E–F and G–H, on Fig. 27, page 148, are first dealt with, the sections A, B, C and D being then worked by performing the operation in each section, commencing at the outer edge of the plate and working the tubes in the sections in circumferential rows towards the centre.

Lastly, the fire-box ends of tubes are beaded by the aid of tool No. 5, shown in Fig. 28, using a hand or pneumatic hammer. At the smoke-box end the two rows of tubes immediately below the lower row of larger superheater tubes and all tubes above these rows must be similarly beaded. If necessary, the finished fire-box ends of the tubes may, after beading, be lightly rolled by the use of tool No. 1.

In the case of the large flues for the superheaters the operations are very similar to those already described, but the fire-box ends of the tubes are swaged down to a diameter considerably less than that of the main body. After the explanation already given, Figs. 29 to 33, on page 148, will clearly explain the operations used in fixing the superheater tubes, Figs. 29, 30, 32 and 33 referring to the fire-box ends and Fig. 31 to the smoke-box ends. In this case the beading tool, No. 5, shown in Fig. 33, is used at both ends of all the tubes.

The arch pipes used for supporting the fire-brick arch in the fire-box, as already described above, are fixed at both ends in the same way as the fire-box ends of the ordinary boiler tubes, except that the copper ferrules are made longer, so that they

project $\frac{1}{16}$ in. beyond the plates on both sides, and that the corrugation of the tubes close to the tube plates is omitted. Figs. 34 to 37, on the present page, show the sequence of operations in the case of the arch pipes.

The steel used by the Pennsylvania Railroad Company for the construction of boilers is of two qualities, one quality being used for shell plates, front tube plates, butt strips and internal flanged staying sheets, and the other quality being employed for inside fire-boxes, fire-box tube plates, and connecting or outside throat or neck plates. The steel for shells is specified to have a tensile strength of 60,000 lb. per square inch, and to give an elongation of 26 per cent. in a length of 8 in. before fracture. The chemical composition desired is as follows:—

	Per cent.
Carbon	0.18
Phosphorus, not above	0.04
Manganese ,, ,, ...	0.40
Silicon ,, ,, ...	0.05
Sulphur ,, ,, ...	0.03
Copper ,, ,, ...	0.03

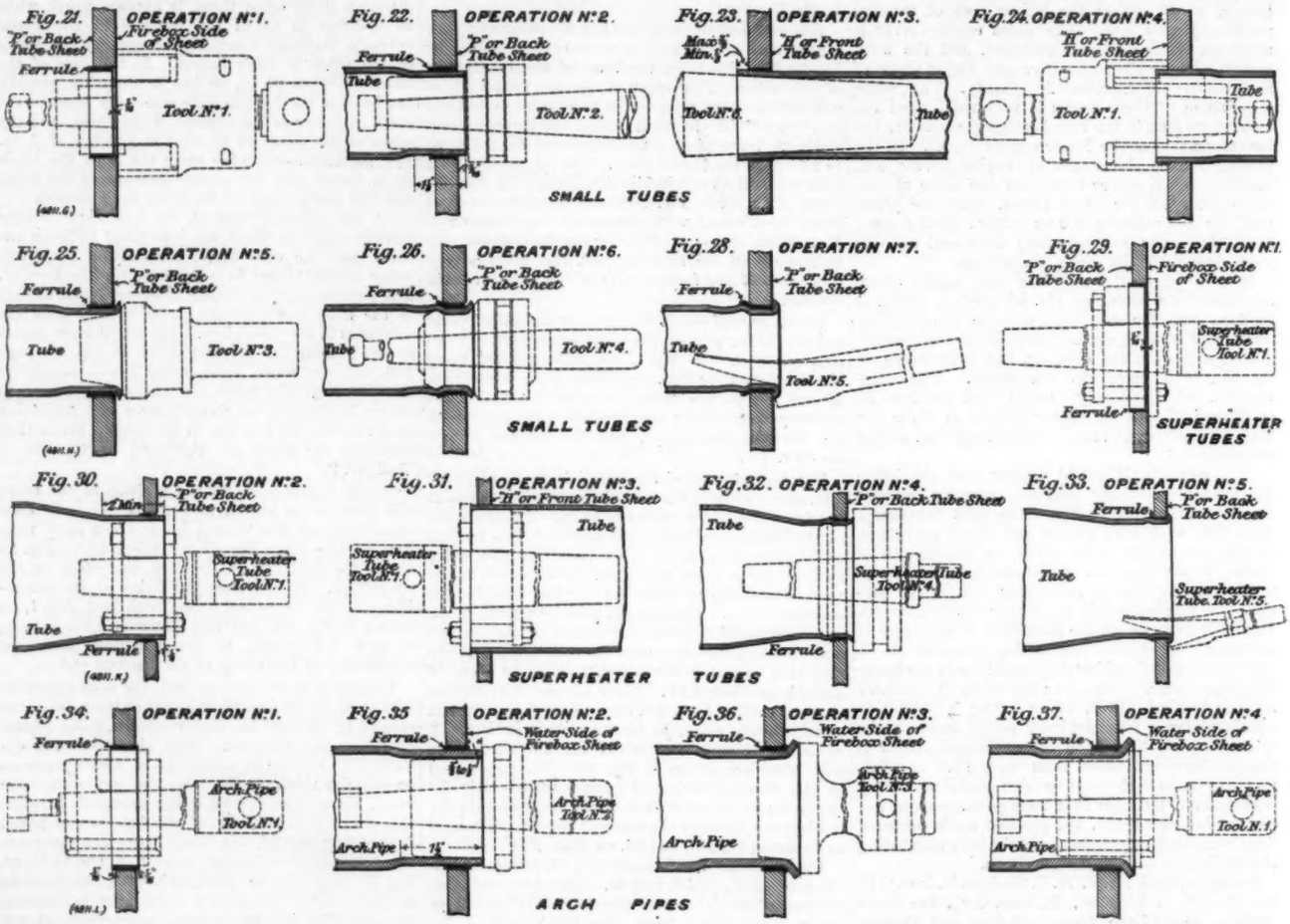
Plates are rejected if the test pieces show a tensile strength of less than 55,000 lb. per square inch, or if the elongation before fracture is less than the quotient of 1,400,000 divided by the tensile strength in pounds per square inch. The steel is also rejected if the analyses shows the presence of more than 0.05 per cent. of phosphorus, or if the tensile strength is over 65,000 lb. per square inch, provided, however, that in the latter case if the elongation before fracture be 28 per cent. or over the plates will not be rejected for high strength.

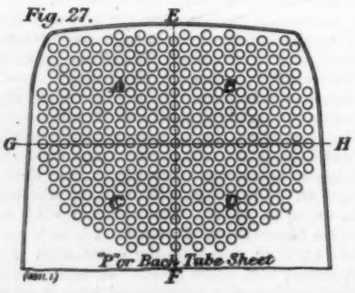
In the case of the steel for inside fire-boxes the tensile strength specified is 60,000 lb. per square inch, with an elongation of 28 per cent. in a length of 8 in. The chemical composition desired is as follows:—

	Per cent.
Carbon	0.18
Phosphorus, not above	0.03
Manganese ,, ,, ...	0.04
Silicon ,, ,, ...	0.02
Sulphur ,, ,, ...	0.02
Copper ,, ,, ...	0.03

Rejection of the steel ensues if the results of the tests show: (1) A tensile strength of less than 55,000 lb. per square inch; (2) an elongation less than the quotient of 1,450,000 divided by the tensile strength; (3) a tensile strength of over 65,000 lb. per square inch (should, however, the elongation be 30 per cent. or over, plates will not be rejected for high tensile strength); (4) any single seam or cavity more than $\frac{1}{4}$ in. long in either of the fractures obtained during the test for homogeneity; or (5) if analysis shows:—

	Per cent.
Carbon, over	0.25
,, below	0.15
Phosphorus, over	0.035
Manganese ,, ...	0.45
Silicon ,, ...	0.03
Sulphur ,, ...	0.045
Copper ,, ...	0.03





In the case of both classes of steel the upper limit of strength for plates $\frac{1}{2}$ in. in thickness may be 68,000 lb. per square inch.

The homogeneity test referred to above as required for steel used for inside fire-boxes is described as follows in the company's specification: "A portion of the broken test piece is either nicked with a chisel or grooved on a machine transversely, about $\frac{1}{16}$ in. deep, in three places about 2 in. apart. The first groove should be made on one side 2 in. from the square end of the piece; the second 2 in. from it on the opposite side; and the third 2 in. from the last, and on the opposite side from it. The test piece is then put into a vice with the first nick about $\frac{1}{4}$ in. above the jaws, care being taken to hold it firmly. The projecting end of the test piece is then broken off by means of a hammer, a number of light blows being used and the bending being away from the groove. The piece is broken at the other two grooves in the same way. The object of this treatment is to open and render visible to the eye any seams due to failure to weld up or to foreign interposed matter, or cavities due to gas bubbles in the ingot. After rupture, one side of each fracture is examined, a pocket lens being used if necessary, and the length of the seams and cavities is determined. The length of the longest seam or cavity determines the disposition of the sheet."

We have already mentioned that the fire-box of the boiler we have been describing is stayed with iron screwed stays. The iron used for these stays is specified to be rolled from a bloom made wholly of puddled iron or knobbled charcoal iron, free from any admixture of iron scrap or steel. The iron is tested for tensile strength, by bending a specimen cold through 180 deg. flat on itself in both directions, and by a vibration test, carried out as follows:—The piece to be tested is threaded in dies with a U.S.S. thread, 12 to 1 in. and firmly screwed

through two holders having a space of 5 in. between them. The holders are so made that the bolt is rigidly held to prevent rocking, and one holder is rigidly secured to the bed of a suitable machine. The holder at the other end is then vibrated in a direction at right angles to the axis of the bolts over a space of $\frac{1}{4}$ in. so that the end of the specimen is deflected alternately $\frac{1}{8}$ in. on each side of the centre line. The rate of vibration does not exceed 50 strokes per minute and the test is stopped on the completion of 2,600 double vibrations, that figure being used as the maximum number of vibrations in calculating the average for a given set of tests. The iron is rejected if (1) the tensile strength is less than 48,000 lb. per square inch; (2) if the elongation before fracture is less than 25 per cent. in 8 in.; (3) if it stands less than 2,500 double vibrations; (4) if 25 per cent. of the samples stand less than 2,400 double vibrations; and (5) if the iron will not take a clean sharp thread with dies in fair condition.

Returning now to the description of the details of the boiler, we give on Plate XVI., in Figs. 47 to 54, details of the fire-grate and ash-pan which are fairly self-explanatory. The fire-grate is of the usual rocking-finger type with interlocking grate-bars. A centre bearer, 5 in. wide, extends along the centre of the grate as shown in the plan, Fig. 47, and on each side of this centre bearer a drop-grate section 13$\frac{1}{4}$ in. wide is located about 4 ft. from the front end of the fire-box. Opposite each drop-grate is a small stationary grate. The grate is arranged to be shaken in four sections, and the rocking levers and their connections are shown in Figs. 47 to 50. It will be noticed that ample air spaces have been provided for in the centre bearer and in the stationary and drop grates.

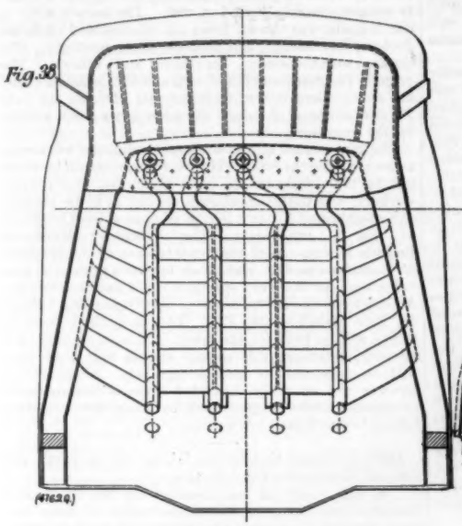
In consequence of the great width of the fire-box, extending far beyond the engine frames, the form of the ash-pan becomes a little complicated, but it will be readily understood on reference to Figs. 51 to 54, on Plate XVI., which show also the arrangement of the dampers filled to the deep portion of the ash-pan which extends down between the frames. It will be noticed that the sides of the ash-pan are so shaped as to give at the top of each side an air inlet 6 in. wide. This is best shown on the right-hand side of Fig. 52.

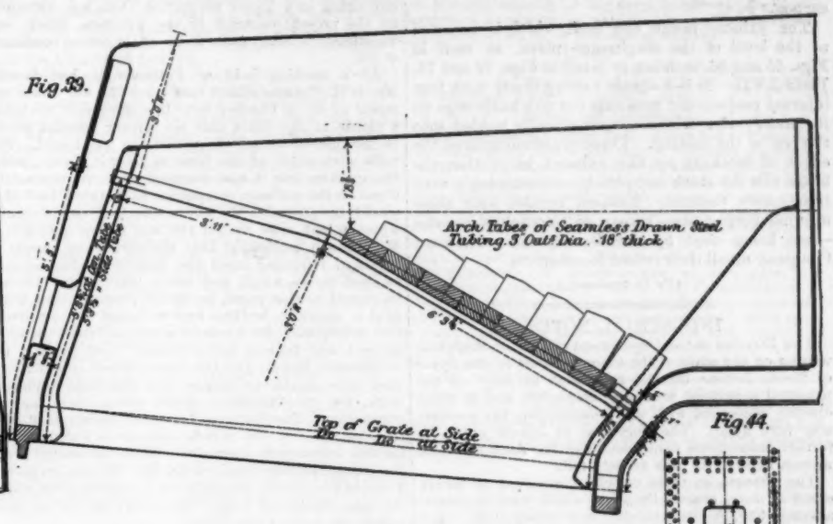
The general design of the smoke-box is shown by Figs. 55 and 56, on Plate XVII, and attention may be called to the large size of the superheater damper, which is mounted on a transverse shaft carrying counter-weights outside the smoke-box on each side of the engine. It should also be noted that there is no connection to the smoke-box tube plate which would more nearly close the opening at the bottom of the superheater-box when the damper is shut. This arrangement is practically self-cleaning, and has been found to make the boiler steam very freely. From the superheater compartment a solid horizontal diaphragm extends forward to about 20$\frac{1}{2}$ in. from the front of the smoke-box, where it meets the sloping front end netting, as shown in Fig. 55. To ensure the proper velocity of the escaping gases, so that cinders may be blown out at the front end, the area of the opening below the diaphragm is reduced by an angle plate which extends some 3$\frac{1}{2}$ in. below the diaphragm at its front edge.

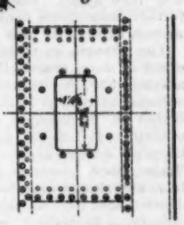
The superheater is of the Schmidt type, and is made up of 40 elements, each of which consists of four 1$\frac{1}{2}$-in. tubes. The fireside heating surface of the superheater is 1,171.85 sq. ft., it thus forming about 24 per cent. of the total boiler-heating surface. The steam pipes from the superheater pass through the sides of the smoke-box and connect to the steam chests at the top, as shown on the right-hand side of Fig. 56.

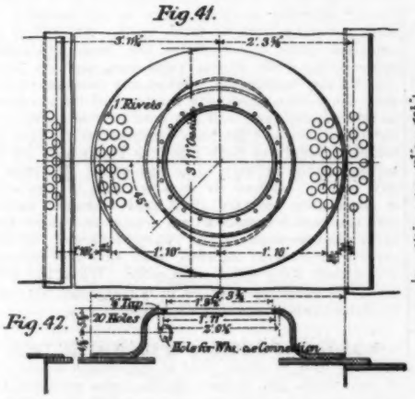
The smoke stack used in connection with the locomotives under notice is illustrated in Figs. 57 to 64, Plate XVII. The upper part is of cast-iron, while the lower, or "lift-pipe," is of wrought iron, the two portions being connected together at the top of the smoke-box as shown in the detailed view, Fig. 57. A special feature is the provision at the top of the stack of an annular passage, shown in Fig. 57, and to a larger scale in Fig. 63. Into this passage are drilled twenty $\frac{1}{4}$-in. holes standing at an angle of 20 deg. to the centre line of the stack, as seen in the views just referred to. The annular passage is connected to a pipe which is led back over the boiler to the cab, where it is coupled to a quick-acting valve placed within easy reach of the engine driver, so that by operating this valve steam jets can be discharged through the openings at the top of the smoke-stack. This device was adopted because it was found that in the use of locomotives which were rather long and high the products of combustion discharged from the stack when the engines were running with steam shut off often settled over the top of the boiler in front of the cab, thus rendering the observation of signals difficult. By the use of the device described, however, it was found that the products of combustion could be carried up 8 or 10 ft. above the top of the stack before they begun to spread out, and thus a clear view of the signals is obtained.

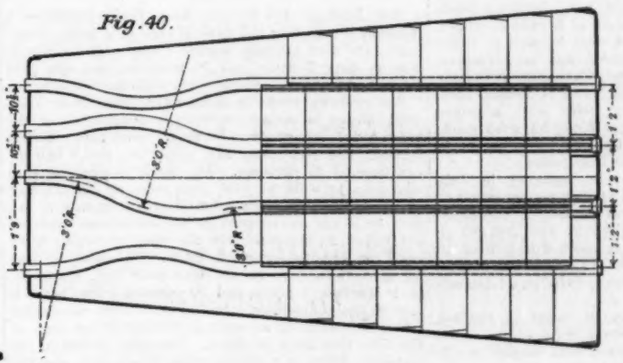
Figs. 66 to 71, on Plate XVII., show the arrangement and details of the steam blower and exhaust nozzle at the base of the lift-pipe which have given the best results. The design of the blower is unusual. As will be seen from Fig. 69 and the enlarged details, Figs. 66 to 68, it consists of a hollow casting made in three parts, which embraces the lift-pipe near its lower end, the annular chamber thus formed

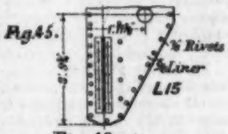












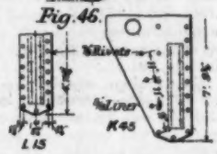


Fig.43. SECTION OF LONGITUDINAL JOINT ON BARREL.

having projecting from its inner side seven nozzles (see Fig. 67), which pass through the lift-pipe, each nozzle having on its upper side a $\frac{5}{16}$-in. hole through which live steam can be discharged up the stack. Tests made with this arrangement show that it is more economical of steam than the patterns previously used, the jets completely filling the stack and producing a better vacuum in the smoke-box. The nozzles also are found to be quite free from trouble due to clogging up. In the sections of the smoke-box given in Figs. 55 and 56, Plate XVII., the steam blower shown in position is of a pattern which has now been discarded in favour of the new arrangement just described. In the old form the steam-blower jets immediately surrounded the exhaust nozzle and the openings were liable to become blocked by an accumulation of grease and carbon.

The exhaust nozzle now used, which is mounted at the level of the diaphragm plate, as seen in Figs. 55 and 56, is shown in detail in Figs. 72 and 73, Plate XVII. It is a simple casting fitted with four internal projections, each tapered to a knife-edge on its under side, which are electrically welded into the top of the casting. These projections have the effect of breaking up the exhaust jet so that the latter fills the stack completely, maintaining a very satisfactory vacuum. Exhaust nozzles with these internal projections—known as Goodfellow nozzles—are being used by the Pennsylvania Railroad Company on all their recent locomotives.

(To be continued.)

INDUSTRIAL NOTES.

The Director of the Department of Labour Statistics, writing on the state of the labour market in the *Board of Trade Labour Gazette*, says that in July all the principal industries were well employed, and in those directly concerned with war requirements the pressure was very great. The depletion of labour owing to further enlistments continued, and the need for more women substitutes was acutely felt.

The changes in rates of wages reported as taking effect in July, practically all of which were increases, affected 336,000 workpeople, and resulted in a net increase of nearly 55,000*l.* per week. The principal bodies of workpeople affected were building trade operatives in London, coal miners in Northumberland, tin-plate makers and iron and steel workers in South Wales, dock labourers in London and at Liverpool, boot and shoe operatives in the Northampton County district, and workpeople in the North of Ireland linen industry. Important changes were also arranged during July (to take effect from June) for workpeople employed in the dyeing and kindred trades in Yorkshire, Lancashire, Cheshire and Derbyshire.

The total number of disputes beginning in July was 31, and the total number of workpeople involved in all disputes in progress was 34,520, as compared with 33,823 in the previous month and 209,261 in July, 1915. The estimated aggregate duration of all disputes during the month was 118,000 working days, as compared with 265,600 in June, 1916, and 1,385,900 in July, 1915.

The average weekly number of vacancies notified to all Labour Exchanges for the five weeks ended July 14 was 39,154, as compared with 40,263 in the previous four weeks, and with 34,000 in the five weeks ended July 16, 1915. The average weekly number of vacancies filled for the same periods was 30,823, 31,785 and 25,714 respectively.

Between July 1 and August 1, 1916, the general level of retail prices of food in the United Kingdom showed a slight decrease, mainly owing to the decline in the price of potatoes; there was also a general reduction in the price of cheese, and imported meat was a little cheaper on August 1 than a month earlier.

Although the decrease in the general level of prices was quite small, it is noteworthy as being the first decline reported since August, 1914.

Taking the country as a whole, and making allowance for the relative importance of the various articles in working-class household expenditure, the average increase in the retail prices of food since the beginning of the war may be put at 60 per cent., which is reduced to 54 per cent. if the increase in the duties on tea and sugar is deducted.

These figures relate to food only, and in estimating the increased cost of living this percentage must not be applied to the total family expenditure, but only to that proportion which is expended on food. It should be remembered that rents of working-class dwellings are not appreciably higher than before the war, and that although many other items of expenditure have increased, they have not advanced, on the average, so much as food. It may be estimated that the average increase in the cost of living of the working-classes, taking food, rent, clothing, fuel and light and miscellaneous expenditure into consideration, between July, 1914, and the present time, is between 40 and 45 per cent., disregarding increased taxation and assuming that the standard of living has not been modified in view of war conditions.

Special meetings of the Executive Council of the National Union of Railwaymen were held recently in London, when it was decided that an application should be made to all the railway companies in the United Kingdom for an immediate increase of 10*s.* per week for the whole of the members of the Union, on the following grounds:—(1) That the duration of the war had extended beyond the period contemplated by the contracting parties to the agreement now in force. (2) That the cost of commodities had risen and was still rising in a higher proportion than was warranted by the present earnings of the members, which were insufficient in many cases to maintain decent conditions of life.

At a meeting held at Portsmouth last Sunday Mr. J. H. Thomas stated that when the war bonus was raised to 5*s.* in October last the agreement contained a clause to the effect that no further demand should be formulated during the period the war lasted. Protests were made at the time as to this clause, added the speaker, but it was accepted after the representatives of the railway companies had stated that they would be prepared to realise changed circumstances which might arise should the war go on indefinitely. Mr. Thomas contended that the agreement should be reviewed following upon the further serious advance in food prices which had taken place since October. In regard to this point, he stated that the high wages paid to munition workers had worsened the position of the railwaymen, for wherever wages had risen the shopkeepers and traders had increased their prices; the railwaymen had to pay the higher prices charged, and they were unable to change and undertake munition work, for the companies would refuse them leaving certificates. The National Union of Railwaymen had, therefore, sent to the railway companies a demand for the 10*s.* advance in question. When the answer from the companies was received he, Mr. Thomas, expected it would necessitate negotiations, in carrying out which the men would not forget that over 100,000 of their colleagues were at the Front.

The *Railway Age Gazette*, New York, publishes a diagram illustrating the typical case of a head brakeman; the man actually worked 1 hour and 5 minutes, was on duty 7 hours and 50 minutes, and was paid for 10 hours. Our contemporary adds the following:—"The printing trade in large cities like New York and Chicago is entirely under the domination of the union. It admittedly employs well-paid skilled labour. The eight-hour day, with time and a half for overtime, is compulsory. The linotype machine man who goes to work at 8.30 finds copy at his machine and is actually at work before 8.35. It is safe to say that he is not interrupted in his continuous work for a total of 20 minutes from the time he begins work until he quits to lunch at 12.30. The same is true for the afternoon. In his eight-hour day, therefore, he is working 7 hours and 20 minutes. The same is true of the compositor. In the steel trade the skilled labourer is actually at work more than 80 per cent. of the time that he is on duty. The same is true in the factory. There is a steady grind which may possibly be a justification for a limitation of hours.

"There is no such corresponding grind in the work of trainmen. The trainman's job is far more analogous in this respect to that of a travelling salesman than to that of a printer or of a steel worker. The travelling salesman may not be actually engaged in selling more than four or five hours out of each 24, but, unlike the trainman, he is on duty often 12 or 14 hours, and in a sense is on duty the whole 24 hours each day that he is on the road. To take another example, how much justice would there be in sailors asking for an eight-hour day and pay at the rate of time and a half for all the remainder of the time that they were on shipboard, exclusive of their watch below? As a matter of fact, even in their watch below they are subject to call at any time.

"The fact of the matter is that a trainman would not be working 8 hours a day if he were on duty 16. In other words, even if the trainmen were asking for an eight-hour day, which they are not, there would be no justification for such a demand."

A second Unemployment Insurance Act, to come into force on Monday, September 4, covers the following trades:—

1. Ammunition, fireworks and explosives.
2. Chemicals, including oils, lubricants, soap, candles, paints, colours and varnish.
3. Metals and the repair of metal goods.
4. Rubber and goods made therefrom.
5. Leather and leather goods.
6. Bricks, cement and artificial stone, and other artificial building materials.
7. Saw milling, including machine woodwork and the manufacture of wooden cases.

The first Act covered the engineering and building trades.

The Volunteer Munitions Brigade, says the Press Bureau, is one of the many voluntary organisations which had their birth in the patriotic fervour of a year ago to increase the output of munitions of war. It appealed especially to those who were unable, from one cause or another, to go on active service, but who could give their spare time during the week-ends to the making of munitions. In this way they performed the very valuable office of enabling the regular workers to secure a weekly period of rest. The membership of the brigade was drawn from all classes and included doctors, barristers, stockbrokers, bank managers, city clerks, warehousemen, travellers and others. The brigade has now concluded a year of its existence and has an excellent record to its credit. During the year 275,000 shifts of 6 hours' duration have been worked by the members.

The importance of the week-end volunteer workers is as great to-day as ever. The continuous strain of working at high pressure is very severe on the regular workers, and if the maximum output is to be secured and maintained for any length of time a weekly period of rest is imperative. The Volunteer Munitions Brigade is now one of the departments of the Ministry of Munitions and it makes an urgent appeal for new volunteers for this very special form of national service. Applications should be made to the Organising Officer, 54, New Broad-street, E.C. The recognised rates of wages will be paid for the work. It is important that all who undertake this service should note that they will be expected to attend regularly. Unless their services can be fully depended upon it is impossible to organise shifts properly and to utilise the week-end labour to the fullest advantage.

With reference to military labour at the ports, the Central News states the following:—

"As the result of consideration by the Port and Transit Committee, an important series of rules has been drafted to govern the employment of military labour wherever civilian labour is unobtainable for ship and quay work at home ports. At each of the principal ports a committee has been established, representing trade unions, employers, and the Naval and Military authorities. When any question of local port congestion arises, the matter will be considered in the first instance, and not until it is established by the employers and the men's representatives that the ordinary supply of dock labour is inadequate are the services of the military to be employed. The rates of pay to the soldiers so engaged will be the same as those for ordinary dock and transport labour, and the men themselves will retain the wages they earn. Representatives of the transport workers express themselves satisfied with this new scheme, which they state works admirably. When the work for which soldiers are called in is completed they will be withdrawn."

At the annual conference of the National Union of Scottish Mine Workers, held at Edinburgh at the end of last week, Mr. Robert Smillie, who occupied the chair, moved a resolution recommending the members of the Union to ballot in favour of the pits being kept open for the production of coal six days a week. The resolution was carried with only one or two dissentients.

In Queensland recently there has been authorised and constituted a new industrial board, called the Life Assurance Canvassers' Board, with jurisdiction extending throughout the South-Eastern Division of the State, making a total of 112 industrial boards authorised under the Industrial Peace Act, 1912. Six of these boards had already been dissolved, and two remained to be constituted. Thus, 104 boards were in existence, and of these 96 had made awards. As a result of the declaration, by Orders in Council of August 17 last, that "metalliferous mining" be a calling within the meaning and for the purposes of the Industrial Peace Act, 1912, two awards for engineers and other iron workers and for surface and underground workers respectively, at the Mount Morgan Mine, were delivered on submissions made to the Industrial Court by the Minister for Public Works. In all 14 awards were recorded, 11 by industrial boards and 3 by the Industrial Court, in addition to 5 judgments by the latter tribunal on appeals from awards of boards. Of the 11 awards delivered by industrial boards, 3 only became operative during the quarter. The total number of awards of the Court and of industrial boards

in force at the end of the quarter was 103, affecting approximately 90,000 workers. Seven industrial agreements, of which four were made subsequent to a compulsory conference, were filed during the quarter. One agreement, however, did not come into operation until January 1 last.

PRODUCING SMOKE TRAILS.

To the Editor of Engineering.

Sir,—I should be very grateful if you would be kind enough to suggest means for providing a considerable volume of light-coloured smoke to indicate direction of wind to aeroplanes. Smudge fires require the whole attention of a man and partially vapourised oil vanishes too soon and does not give a long enough trail. What we want is a fool-proof appliance requiring minimum attention, and the problem appears to be a difficult one.

With apologies for troubling you.

Yours faithfully,

Flying Officer.

August 5, 1916.

HOW SHALL WE PROMOTE INDUSTRIAL PROGRESS?

To the Editor of Engineering.

Sir,—There is a danger at this time, when a large number of Committees have been appointed to explore different questions bearing upon the industrial and commercial welfare of the country, that their effort may be largely wasted unless it can be focused upon certain definite proposals which should gradually emerge out of the discussion of broad principles and general questions. Such proposals should be practical in their scope, and of a kind which could be generally applied—with modifications to suit individual cases—to the industries for which they are suitable.

With a view to assisting this process of crystallisation of ideas, as applied to the Engineering industry, I should like to put forward the following three proposals. They are intended to promote the development of intelligence among the skilled workers, co-operation between workers and employers, and convenience in marketing the product of the industry.

1. It is generally felt that a more thorough technical training of the skilled workers will be necessary in the future than obtained in this country in the past. Some firms have devoted much care and time to this question, and have in operation in their works well-thought-out schemes for encouraging their employees in this direction; but there are still many employers who take no interest in the question, whose workers in consequence do not get the training they ought to, and the industry as a whole suffers accordingly.

My suggestion is that it should be made a statutory obligation on all employers to prepare and submit a training scheme for their apprentices (the term to include all employees under twenty years of age). The scheme could be submitted for approval to the local education authority, or to the Board of Trade, or to the proposed Ministry of Industry, if such be formed. Wide latitude should be allowed to vary the scheme to suit each firm's requirements, but in all cases it should include suitable technical instruction, rewards for taking advantage of same, and a graduated practical training in the trade which is being learnt.

2. It is generally recognised that close co-operation between the workers and the employers is essential if British industry after the war is to hold its own against foreign competitors. Under the Dilution of Labour Scheme, Committees have been, or are being, set up in many engineering works which include members representing the workers and members of the firm. These committees might very usefully be made permanent, and their powers enlarged to cover a wide variety of industrial questions, wages, demarcation of trades, working hours, &c. Discussion of these questions in the committees would often materially advance their solution, and this method would be much better than the sending of deputations to the management on particular questions, which is the clumsy and most unsatisfactory plan that at present more or less holds the field. The committee should meet regularly in working hours, and all industrial questions should come before it in the first place; failure to agree would, of course, result in recourse to other forms of negotiation, but an experienced committee would be much less likely to fail in this way than the extemporised committees or deputations which at present handle these questions when they first arise.

3. It would be a great convenience to the buyer of engineering material, machine tools, fittings, plant, &c., if he could visit one central market to see what he wanted and talk over his needs with the seller, rather than—as at present—having to trust to catalogues and correspondence or visiting a number of show-rooms. Could a permanent exhibition not be established in, say, the four centres—London, Birmingham, Manchester and Glasgow—at which all the selling firms would show their stock, with facilities for demonstrating the machines at work, and where the buyers could see the different makers' product, talk it over with the agent, and in the course of an hour see more than he can at present do in a whole day? If a company were formed to run these central markets, the exhibitors to be shareholders, and each market to be in general charge of a competent engineer, much useful information could be collected as to what was in demand, and new plant could be quickly brought to the users' notice; if the buyer did not find what he wanted in one market, a visit to one of the other centres in search of it would not be the formidable task which now faces him if he has to go to two or three towns widely separated to look at possible purchases. If the object of the markets were solely to promote British industry, then only British-made material would be shown; it would be for the company itself to decide whether that would be for their and the country's best interest.

I apologise for taking up so much of your space, but I hope that these suggestions may prove of some value in considering how best to promote industrial progress after the war.

I am, Your obedient servant,

Neil J. Maclean.

Anniesland, Glasgow, August 9, 1916.

DRAUGHTSMEN.

To the Editor of Engineering.

Sir,—I have followed with interest the recent correspondence in your columns on the subject of the position of draughtsmen in the engineering and shipbuilding trades. As a leading draughtsman in an important firm of engineers, I may state my reasons for having taken an active part in the formation of a branch of the Association of Engineering and Shipbuilding Draughtsmen in the Merseyside District.

Apprentices are usually informed that as a reward for industry and merit in the workshop and application at their evening classes, they may be permitted to complete their apprenticeship in the drawing office and thus qualify as junior draughtsmen. They discover, however, when too late, that from a financial point of view they would have been well advised to remain at the bench, and that unless an exceptional course of good fortune befalls them they will pass a good many years before they receive a living wage, being happy if their salary is raised annually by 2s. 6d. per week.

Employers, when appealed to, are wont to reply that they recognise the justice of the claim for a salary adequate to the importance of the work and responsibility of the draughtsman, but that they have to bear in mind the practice of other firms with whom they are in competition.

The unfortunate draughtsman must, therefore, be content to accept the position, while he witnesses his fortunate contemporary in a bank or cotton office enjoying a status and salary perhaps 50 to 100 per cent. better than his own, with a responsibility which is very considerably less. The alternative is to look about for another job just when his training and experience would be of the highest value to his employer.

A leading draughtsman has frequently to undertake the oversight of four or five sets of plans simultaneously, involving both arrangement and details differing very greatly from one another, together with a vast amount of miscellaneous work of a highly technical character, and the heavy matter of correspondence with owners, inspecting bodies, sub-contractors, and other firms building in conjunction. It is quite possible for him to save—or lose—to his employers the value of his salary every week, and one wonders what in strict justice his salary ought to be under these conditions.

I do not write this in any spirit of bitterness, as I am bound to acknowledge the fact that fidelity is, in my experience, always highly appreciated by superiors, except in the matters of standing and salary, when the position of helplessness is assumed. My appeal, therefore, to draughtsmen of all ranks, is to join the Association seeking to define and regularise their qualifications, and then, with the courtesy and strength of those who claim what is a just and right return for their services, to stand together for the permanent recognition and advancement of their highly important profession.

Information in regard to the Merseyside Branch of the Association will be gladly forwarded on application to F. J. Lees, Esq., Solicitor, 45, Hamilton-square, Birkenhead.

I am, Sir, Yours faithfully,

Non nobis solum.

To the Editor of Engineering.

Sir,—As some misunderstanding has arisen among draughtsmen as to whether they are entitled to the benefits of the recent recommendations of the Ministry of Munitions with regard to extra payment for holiday periods, I shall be much obliged if you will insert in your next issue the enclosed letter which I have received from the Department.

Yours faithfully,

L. Blair (*Secretary*).

The Association of Engineering and Shipbuilding Draughtsmen, 94, Hope-street, Glasgow, Aug. 16, 1916.

Ministry of Munitions of War,
6, Whitehall-gardens, London, S.W.
August 10, 1916.

L. Blair, Esq.,
Association of Engineering and Shipbuilding Draughtsmen,
94, Hope-street, Glasgow.

Sir,—I have to refer to your letter of July 31 relating to the question of holiday rates of pay in regard to draughtsmen, and in reply I have to inform you that all classes of workmen as defined in Section 12 of the Munitions of War (Amendment) Act, 1916, are intended to be included in the Departments' recommendations regarding the extra payments of holiday periods.

I am, Sir, your obedient Servant,
(Signed) R. H. Handyside.

THE AIR RESISTANCE OF FLYWHEELS.

To the Editor of Engineering.

Sir,—With reference to the query by "Interested" regarding the Air Resistance of Flywheels, about seven years ago the writer carefully tested one of Messrs. Davey, Paxman and Co.'s horizontal positive valve-gear steam engines in order to find the amount of the loss of power on the engine from this cause. The flywheel was grooved for 16 ropes, and owing to the wide rim it was made with double arms. The diameter was 16 ft., and the speed 100 r.p.m.

From indicator diagrams taken when the engine was running at normal speed quite light, with the ropes removed, and with the wheel not lagged, it was found that the power developed in the cylinders was 61 i.h.p. After the flywheel arms had been boarded up the friction cards, taken under the same conditions as before, showed that the power was reduced to 48 i.h.p. This saving was greater than had been anticipated, but in the calculations made before taking the tests only the known factors were taken into account, and possibly the effect of the double arms may be greater than that of single arms with equivalent surface.

The area acted upon by the air is the length × breadth × number of arms, and the pressure in lb. per square foot against a plane surface is equal to $0.00164 \times$ velocity in feet per minute; multiplying this by 0.7854 gives the pressure against the round arms of the flywheel. When the average velocity of the arms is known, the power required to overcome the air resistance can be calculated, and is $\frac{\text{area in sq. ft.} \times \text{pressure} \times \text{velocity}}{33{,}000}$.

I am, Yours faithfully,

A. Vincent Clarke, A.M.I.C.E., M.I.M.E.

7, The Park, Yeovil, August 12, 1916.

The British Machine Tool Industry.—There has just been issued under this title a brochure containing a lecture on this subject delivered before the Keighley Engineers' Association by Mr. J. Judson, 50, Marsham-street, Westminster, who will be pleased to send copies free to anyone on request. He strongly advocates the use of British-made machine tools in preference to imported machines, and generally an improvement in the design of our machines. This, he states, depends upon: "(1) Admission of shortcomings in the past. (2) Collective organisation of effort. (3) Subordination of 'business jealousy' to business efficiency—meaning: (4) Patriotism in its true commercial sense. (5) A more friendly intercourse between employers and employees, a condition perhaps not fully appreciated by the lawyers in high places. (6) A great combined effort to make the machine tool industry of Great Britain more and more self-supporting and independent of foreign sources of supply. (7) A strenuous effort to secure better representation of business men in our national affairs. (8) And last, but not least, the glorious ideal of perfect business efficiency."

Activity at Niagara Falls.—There has been a great development of various industries in the Niagara district during the past 12 months, plants having been enlarged along the Niagara between Buffalo and Tonawanda, at Niagara Falls, and in Buffalo. The total outlay which has been made is estimated at 20,000,000 dols. A considerable portion of this new development just north of Buffalo is attributable to the establishment on the river front, near the Grand Island ferry, of a steam generated electric power plant of the Buffalo General Electric Company, which will have an ultimate capacity of 200,000 h.p. This power station is intended to supplement the power developed at Niagara Falls. The first section of the power plant, which will generate 80,000 h.p., will be completed during the autumn. The initial equipment will comprise two 20,000 and one 30,000-kw. Curtiss steam turbo-generators. The construction and equipment of the whole plant proposed to be erected will involve an outlay of 3,000,000 dols. The Semet Solvay Company, which has recently purchased a site of 50 acres on the Road River adjoining the Wickwire Steel Company, is constructing 60 by-product coke ovens at a cost of 2,000,000 dols. The Acheson Graphite Company, Niagara Falls, is about to build a large branch plant, to be known as "plant No. 3," upon a site recently purchased, adjoining the Buffalo General Electric Power plant on the Niagara. The branch plant now about to be erected will cost 500,000 dols.

Indian Railway Management.—The question of providing adequate railway facilities for the growing commerce of India is one of the most serious problems with which the Indian Government is confronted. An important step has been taken by the Indian Railway Board with a view to determining a definite policy for the future. In a communication from Simla to the leading commercial bodies of India it is stated that the investigation by the Board of the comparative advantages of the management of railways by companies on the one hand, and by the State on the other, has now been completed, and it has been found impossible to base any definite finding upon the statistical results worked out. The Board has, accordingly, frankly adopted the course of inviting the opinion of commercial bodies on the subject. These bodies have had practical experience of the virtues and failings of railway management, and they are asked to state whether in their opinion State-managed or company-managed lines have given the best services to the public. Mr. Couchman, member of the Railway Board, has been making what is known as a monsoon tour. He was last spoken of as at Naini Tal, where he inspected existing arrangements and examined proposals for a wire rope tramway. Later on Mr. Couchman was to proceed to Bareilly, where he was to inspect the Rohilkhand and Kumaon Railway. Still later, he was to proceed to Lucknow for the purpose of conferring with the agent of the Oudh Rohilkhand Railway Company. At Dhanbaid, Mr. Couchman was to devote his time to sundry proposals relating to collieries, and he was to accompany Sir G. Barnes through the local coalfields, returning subsequently to Calcutta.

THE MACLAREN MARINE PARAFFIN ENGINE.

CONSTRUCTED BY MESSRS. MACLAREN BROTHERS, LIMITED, ENGINEERS, DUMBARTON.

Fig. 1.

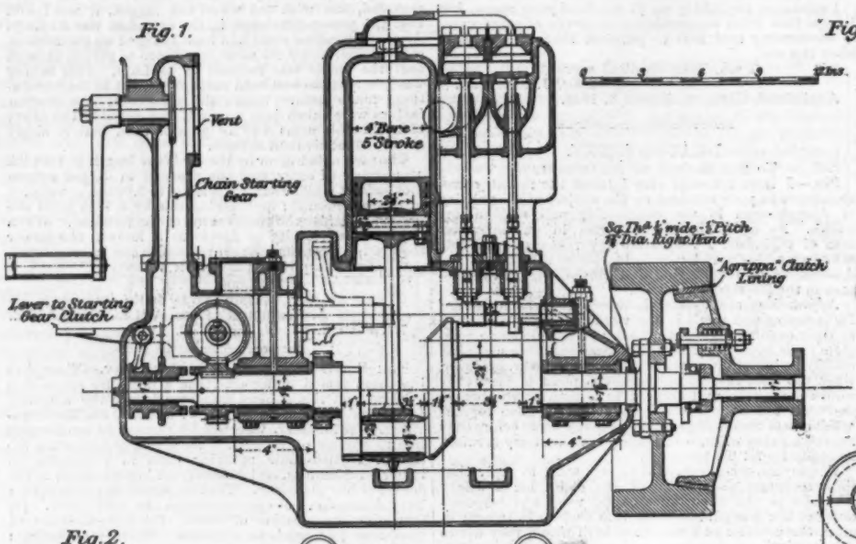


Fig. 3.

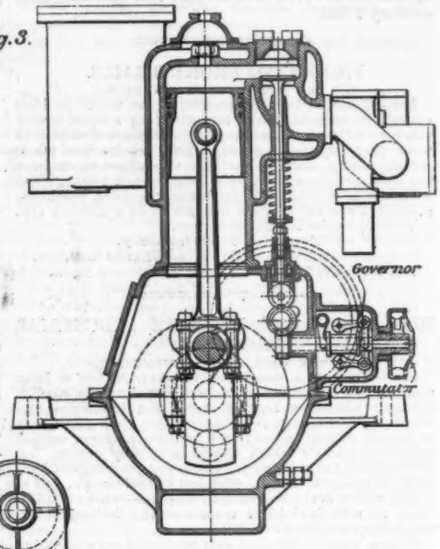


Fig. 2.

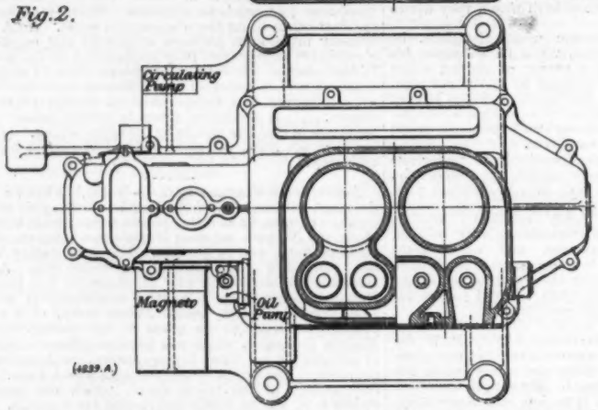
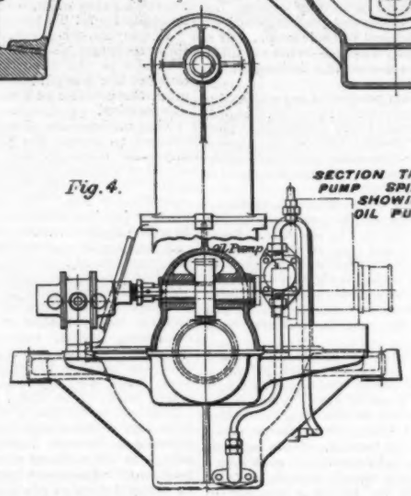


Fig. 4.



We illustrate on this and the opposite page the MacLaren paraffin motor, which is manufactured by Messrs. MacLaren Brothers, Limited, motor launch and motor yacht builders, Dumbarton, in three sizes, viz., with two cylinders, 8–10 brake horse-power, four cylinders, 16–18 brake horse-power, and six cylinders, 24–28 brake horse-power. The cylinders have a bore of 4 in. with a 5 in. stroke, and the normal speed is 800 r.p.m. Accessibility has had special attention, all working parts being removable bodily for overhaul, while the lower section of the crank case remains in place upon the bearers. With this arrangement no oil is lost, and the alignment of the shaft is not disturbed.

The cylinders are cast in pairs, the water jackets and heads being in one piece with the cylinder casting, and the valve pockets are water cooled. As will be seen from Figs. 1 to 3, the valves are all on the same side of the combustion chamber, while the camshaft is operated from the crankshaft by means of machine-cut gears of case-hardened steel and gunmetal. It may be mentioned that the cams are connected to the camshaft by feathers as well as by taper pins. The camshaft is supported at each end by plain bearings, which are supplemented by intermediate ball bearings in the case of the four and six-cylinder models. A special feature of the MacLaren motor is the solid forged flange on the end of the crankshaft, to which the flywheel is attached by bolts.

Forced lubrication is employed for all working parts, which, together with the starting gear, are entirely enclosed. The main bearings and connecting rod bottom ends in the four and six cylinder engines are supplied with oil from the gear pump driven off the cam shaft (Fig. 4), the pressure being indicated by a gauge fixed to the engine case.

Ignition is by high tension magneto of the water-tight type, driven from the cross shaft at the fore end of the engine. The ignition, timing, and throttle levers are all controlled from the outside of the casing by means of levers on quadrants which can be locked in any desired position. The seacock and circulating water intake are of the Admiralty type and of gunmetal with gunmetal gland connections. The seacock is of the straightway wheel valve type, while the strainer cover reaches above the water line, thus allowing the strainer to be cleaned while the engine is working.

Of particular interest is the vaporiser and carburetter, in that it embodies the application to low-powered engines of blowlamp heating for starting on paraffin. The arrangement consists of a simple casting, to the outside of which the blowlamp is applied for a few minutes before starting up. There is also a special arrangement whereby the engine can be started on petrol and be changed over to run on paraffin by a movement of the throttle lever. In this arrangement the petrol vapour does not go through the paraffin vaporiser, consequently a suitable combustible mixture is supplied at once to the cylinders, whether the engine is hot or cold, thus eliminating the starting difficulty which is often experienced with the ordinary type of vaporiser when it is too cold for starting on paraffin and too hot for petrol.

University of London, University College.—We have received from the Secretary of University College, Gower-street, W.C., the new issue of the handbook of the Faculty of Engineering, for the session 1916–17. It gives complete information on the entrance requirements, on different courses in the various branches of engineering, &c.

Marine Engineers for the Navy.—The Admiralty are still desirous that marine engineers who are free to transfer their services to the Royal Navy or Auxiliary Branches, where their training and experience will at once be of value to the State, should apply to the Inspector of Recruiting, Admiralty Recruiting Department, Great Scotland Yard, who will afford applicants full information and every assistance. Marine engineers who have enlisted in the military forces of the Crown must obtain, in the first intance, the consent of their commanding officers to a transfer.

TURBO-COMPRESSOR FOR A MIDLANDS COLLIERY.

The development of the turbo-compressor during the past few years is only one degree less remarkable than that of the steam turbine. Machines have already been built compressing as much as 60,000 cub. ft. of free air per minute and yielding pressures up to 170 lb. per square inch (gauge), and it is certain that these figures will be exceeded in the near future. The popularity of the type is due to certain very valuable characteristics. Thus, although it is not possible to attain as high an efficiency with the compressor element taken *per se* as with a reciprocating machine, the fact that it is coupled direct to a steam turbine, the efficiency of which is much greater than that of the steam end of ordinary reciprocating compressors, generally results in a higher overall efficiency of the plant, taken as a whole. The space occupied and the cost, both of the plant itself and of the buildings and foundations necessary, is very much less than would be required for a reciprocating compressor. No internal lubrication being necessary, the air is delivered oil-free, which is in some cases, as when the air is used for certain chemical processes, a matter of the utmost importance. The absence of pulsations of pressure is an additional advantage, and finally, where exhaust steam is available, the compressor may be run with little or no addition to the boiler plant already supplying the winding, hauling or rolling-mill engines.

On page 156 we illustrate a compressor of this type recently constructed by the British Thomson-Houston Company, Limited, Rugby, for a large colliery in the Midlands, where the air is required for a variety of purposes below bank. This machine is designed to deliver 5,000 cub. ft. of free air per minute at a pressure of 80 lb. per square inch gauge, but is capable of taking a considerable overload, and of compressing at need as much as 6,250 cub. ft. of air. Large fluctations in the demand have very little effect on the pressure. In the current working

THE MACLAREN MARINE PARAFFIN ENGINE.

CONSTRUCTED BY MESSRS. MACLAREN BROTHERS LIMITED, ENGINEERS, DUMBARTON.

(*For Description, see opposite Page.*)

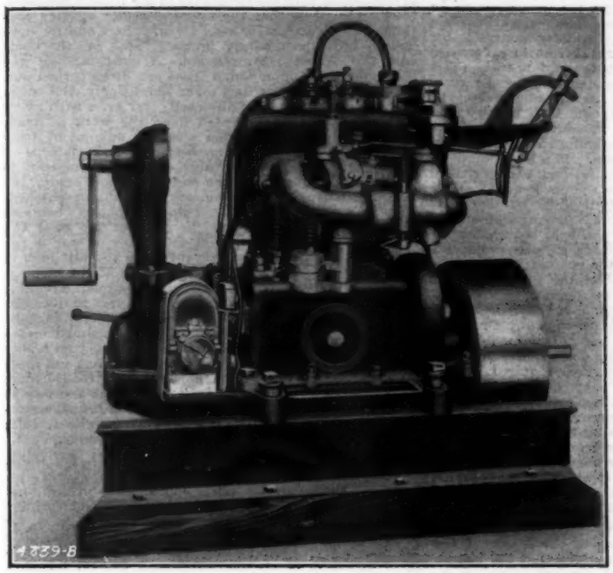


Fig. 5.

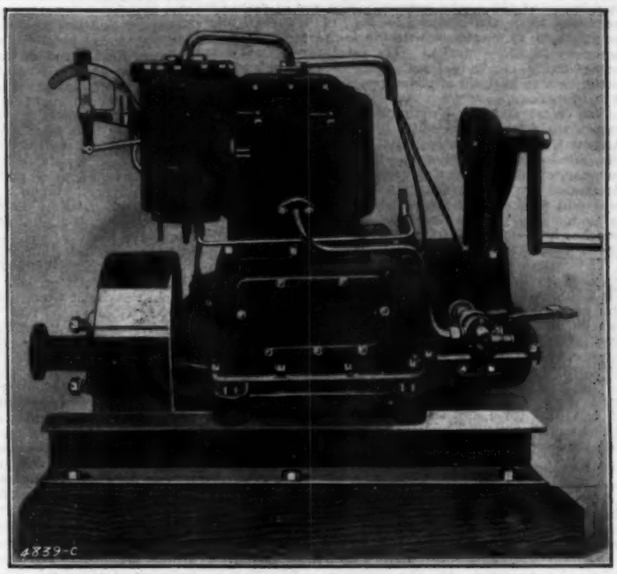


Fig. 6.

of the machine the demand varies within 30 seconds from as little as 1,500 cub. ft. per minute up to its full rated capacity, but the efficiency of the governing is such that the consequent change in the pressure does not exceed 2 lb. per square inch.

The compression is effected in 13 stages, grouped into two independent casings, mounted in line with and driven by a Curtiss steam turbine running at 4,600 r.p.m. In this machine no intercooler has been provided between the two sections of the compressor casings, since the terms of the contract did not include a demand for a low temperature of delivery, but each stage is carefully water-jacketed, so that the compression curve lies well below the adiabatic. The impellers are of high tensile steel fitted with bronze rings in their hubs, so that when forced on to their shafts the contact is between bronze and steel and not between steel and steel; this greatly facilitates the renewal and replacement of the impellers when desired and makes it possible to adopt forced fit allowances sufficient to ensure that the impellers remain tight on the shaft even at the highest speeds of rotation.

The flow of air through the two casings is arranged so that the net end-thrust is practically nil. The two shafts abut in the centre pedestal, the drive being transmitted through a flexible coupling of the claw type. To take up any residual thrust and for adjustment purposes a thrust block is also provided at each casing. A large ratio of casing diameter to impeller diameter has been adopted so as to obtain more effective jacketing, and to increase the cooling effect special cast-iron blades are provided in the air passages between the stages, which increase the cooling surface and also serve as guides to the fluid as it flows. Owing to the precautions noted the compression curve is, it is stated, nearly isothermal. The glands used to pack the shaft at each stage are of the same type as used by the builders in their steam turbines. They consist of four-part bushes of a special alloy. Numerous serrations are provided on the internal surface of the bush, the inner edges being turned to a diameter slightly smaller than that of the shaft. The four parts of the bush are held together by suitable springs. Once the serrations are worn down to the shaft size, however, the pressure of these springs is taken not by the shaft, but by shoulders on the diaphragms which limit the inward motion of the gland components. If the shaft whips, however, these components can open out, being returned by the springs to their normal position when the disturbance disappears. A similar packing is used to prevent leakage at the inlet annuli of the impellers.

The pressure of the air at the delivery branch is maintained constant irrespective of the momentary demand by suitably varying the speed of rotation. This is effected automatically by a spring-loaded piston which is exposed to the delivery pressure. This piston operates a steam relay which controls the supply of steam to the turbine. As already stated, the variations in the rated pressure of 80 lb. per square inch do not in the actual operation of the machine exceed 2 lb. per square inch.

THE RENEWAL OF THE GERMAN COAL SYNDICATE.

In July there was a meeting of the mine-owners belonging to the Rhenish-Westphalian Coal Syndicate, at which the question of the prolongation of the syndicate beyond the present temporary arrangement came up for discussion. It was stated that a considerable portion of the members had unconditionally agreed to the proposed five years' prolongation of the syndicate. On September 15 another meeting is to take place, and in case no definite arrangement is arrived at on that day a further meeting will be held on October 15.

The circular of the Coal Syndicate which was sent out in the early part of June was to the effect that the Board considered a five years' prolongation on the basis of the existing agreement was desirable. The existing allotment agreement was to be looked upon as fundamental, subject to some minor alterations in connection with mines in a state of development and the increased local consumption by concerns which comprise both ironworks and coal mines. Applications bearing upon this latter question were to be handed in before July 15, and although there are differences which have not yet been disposed of, the main difficulty arises from the question of sales outside the syndicate. Some influential members demand that the so-called free trading firms, and the long-period contracts they have with several mines, shall disappear from the new syndicate. This demand has been met with strong opposition not only from the private mines concerned, but also from the Prussian Crown mines, which only of late years have dealt with such trading firms. Nothing accurate has transpired as to the exact position of this question, but a decision must in any case be made at the meeting to be held on October 15, inasmuch as the Prussian Minister of Commerce informed the Coal Syndicate that preparations for a compulsory coal syndicate would be made if a voluntary renewal of the syndicate had not been brought about by that date. The present temporary coal syndicate agreement expires on March 31, 1917, while the mines will be at liberty to sell on January 1, 1917, if no prolongation has been agreed upon by that date. It may, however, be taken for granted that a renewal or prolongation of some kind will be arranged.

During June the sale of coal amounted to 5,852,811 tons, or 72.36 per cent. of the allotment, which stood at 8,088,858 tons. The output amounted to 7,347,464 tons against 8,435,478 tons, the number of working days in June being 4½ less than during the preceding month. The sale of coke amounted to 2,249,839 tons, and of briquettes to 294,537 tons. The percentage of the allotment in the sale of coal, 72.36 per cent., represents the highest figure since the commencement of the war, the next highest being for June, 1915, with 70.16 per cent.

Personal.—The Engineering Improvement Company, Limited, 4a, First Avenue Hotel-buildings, High Holborn, W.C., state that they have made arrangements with Messrs. Vickers, Limited, to manufacture their "Perfloc" nuts.

Female Labour in German Mines.—From the very beginning of the war the German mining industry has been very seriously handicapped by shortage of labour, and female labour is being exploited on an increasing scale. It is now stated that the number of female hands employed in the mining industry of Germany amounts to 45,500, against 5,500 at the beginning of the war.

German Bounties and British Industries.—Sir Robert Hadfield, F.R.S., writing on this subject, says:—"Over 90 per cent. of the manufacturers connected with the various branches of the German steel trade are members of a syndicate, by which the whole organisation of the industry, including selling and fixing of prices in the home and foreign markets, is regulated. In order to stimulate German exports to this country a system has been arranged by which the German manufacturers invoice goods to British buyers at below the market price, receiving from the syndicate a bounty on each ton exported, which enables them to show a profit. In this way they are enabled to quote prices at which the British manufacturer could not possibly sell, except at a considerable loss. Thus the Germans are able, even when trade is bad, to keep their furnaces going and their workpeople and machinery fully employed. Their costs per ton of output are reduced to the lowest possible point, and German manufacturers have been able to lay down plant on a scale impossible to their British competitors. As an illustration of the extent to which our trade is handicapped by the bounty system it may be mentioned that just before the war the export bonus granted by the Steel Works Syndicate was increased to 15 marks per metric ton. High bounties were also granted by the Pig-Iron Syndicate on exported goods, and by the Rhenish-Westphalian Coal Syndicate for fuel used in producing iron for export. It is not too much to say that the British steel manufacturer has by this means been handicapped in competition with his German rival to the extent of 15, in some cases 25, per cent. The result has been seen in a serious shortage of steel supplies in this country at the outbreak of the war. If the influx of bounty-fed steel is allowed to continue unchecked there is a danger of other industries—for instance, the textile trades—being attacked in the same way. The most obvious step towards removing this element of unfair competition is to compel the foreign exporter to invoice his steel to the British consumer at the full value. In the case of exports from this country the law requires this to be given on the invoice of the exported goods, and it should be possible to insist that all goods entering the country should be invoiced at their full and proper value.

HIGHER PRICES IN THE GERMAN IRON INDUSTRY.

In spite of endeavours in the past of the Government to stay the upward tendency in the quotations of the German iron industry, it still persists. The Pig-Iron Union gave the sales for August free at generally unaltered prices, but an exception was made for hematite, for which the quotation was raised 20 marks and now stands at 142.050 marks per ton. The rise in price for hematite since the commencement of the war now amounts to 64 marks, whilst for foundry pig it only amounts to 21.50 marks. This price for hematite is now about 50 marks higher than for foundry pig, whilst the difference in times of peace generally ranges between 5 to 10 marks.

The West German Union of Iron Merchants have raised their prices generally 10 marks per ton from August 1, and similar steps have already been taken by the Silesian iron merchants. This has caused some surprise, as no general rise in prices has recently been demanded by the works, but the works' quotations represent minimum prices, at which, however, but little is sold. The works, owing to the scarcity of many articles, hold out for, and generally are able to obtain, prices which are in excess of the official quotations.

The export price for bar iron has also been raised, varying somewhat according to the different countries; for Holland, for instance, it is 5 gulden per ton, but on the whole an average rise of 10 to 12 marks per ton can be assumed. At this increase a limited quantity was given free to the end of October. A further conference of the export works will be held, at which a further rise of quotations is likely to be discussed.

The production of pig-iron in the German customs union during the month of June amounted to an aggregate of 1,081,007 tons, against 1,112,574 tons for the preceding month, 999,000 tons for June, 1915, and 1,531,000 tons for June, 1914.

Department of Labour Statistics.—The offices of the Department of Labour Statistics, at which the *Board of Trade Labour Gazette* is prepared and edited, are being removed, and in future all communications in connection with this journal or with labour statistics should be addressed to the Director, Department of Labour Statistics, 13, Albemarle-street, Piccadilly, London, W.

Locomotive Feed-Water Heaters: Erratum.—In our issue of August 11, page 144, we published an abstract of a patent specification for an invention concerning locomotive feed-water heaters (No. 7774 of 1915). By a printer's error the name of the patentees were given as G. H. Williams and E. S. Luard. The former name should have been Willans.

"Anuario de la Industria Espanola."—We have received a copy of this Spanish Directory for 1916, the sixteenth edition, published by the Revista Minera, Metalúrgica y de Ingenieria, Madrid, at the price of 7*s*. It contains information on all the Spanish mines, classified according to metals and provinces, and on all metallurgical, electrical and chemical societies established in Spain, with their capital, addresses and administrative boards. The book also gives a list of all Spanish civil engineers, with their addresses, and data on the railway companies. The fees of the School of Mines Laboratory for examining and analysing ore are quoted, also the Customs duties. Special chapters deal with the laws, rules and regulations governing mining and metallurgy in the country.

Large German War Profits.—The Becker Steel Company, which was started in 1908 and had some difficulties to begin with, paid its first dividend of 6 per cent. for the year 1911–12; it then advanced to 12 per cent. for 1913–14. and, thanks to the war, jumped to 25 per cent. for 1914–15. It has now declared a dividend of 30 per cent. for the year ended June 30, 1916. Including 1,560,424 marks carried forward from the preceding year, the gross profits for last year amount to 9,882,748 marks, against 6,040,169 marks for the previous year; a sum of 2,561,656 marks is reserved for war profit tax, &c., writings-off account for 1,506,646 marks; leaving net profits amounting to 5,036,638 marks, against 4,277,761 marks for the preceding year, 1,672,640 marks being carried forward. The share capital is 8,000,000 marks.

Shipbuilding in Japan.—We read in the *London and China Telegraph* that the project of Mr. Asano, president of the Toyo Kisen Kaisha, to establish a shipbuilding yard in Yokohama, has received a setback, and he is now confronted with the necessity of choosing another site. Mr. Kobashi, director of the Engineering Bureau in the Home Office, is quoted by the *Kokumin* as stating that the application filed by Mr. Asano for permission to reclaim part of the Yokohama harbour for the purpose of constructing a shipbuilding yard has met with the disapproval of the Harbour Investigation Commission, which, after deliberate consideration, decided that the building of the yard within the limits of Yokohama harbour was likely to impede future improvement of the harbour. Mr. Asano is determined to proceed with his undertaking as quickly as possible, selecting as the site the reclaimed ground at Tsurumi, where he originally intended to build his yard. At Tsurumi Mr. Asano owns reclaimed ground covering an area of some 100,000 tsubo (395,380 sq. yards), of which 50,000 tsubo is intended for the sites of a new glass factory, the remaining 50,000 tsubo being at his disposal for the shipbuilding yard.

NOTES FROM THE UNITED STATES.

Philadelphia, August 2.

The characteristic feature of the steel market is the renewed demand, chiefly for shells of the 8 and 9.2 sizes. Orders have been placed within a week for a large number of such shells; negotiations are pending this week for about a similar quantity of 6 and 12-in. shells; scarcely any business is being done in the 3-in. size, as the demand is met from European sources; an enormous demand is also on for other steel products for export, such as Bessemer and low phosphorus pig-iron, of which some 250,000 tons possibly are now under contract for delivery for the rest of this year; in view of a decrease in pig-iron production and the heavy orders to be filled it is believed that prices will harden later in the year. Material for implements is being hastily ordered for 1917 delivery. Railroads are holding off with a very few exceptions; the Pennsylvania, in addition to its very large orders, is credited with preparing specifications for an additional supply of 5,000 cars. It is also inquiring for large tonnages of plates, shapes and bars for next year's delivery. Japan is also in the market for a small lot of 5,000 tons of plates, but it must be delivered during November and December; structural material continues weak in the face of withheld requirements; material for munition is hardening in price; general industrial activity continues at the top notch. Nothing definite has been arrived at concerning the threatened railroad strike. Government interference will be resorted to before the final conclusion is reached. There is no indication of a weakening in prices in any direction. Estimates are made as to the volume of pending inquiries for munition material, but nothing definite can be stated beyond the fact that the quantities required exceed any reasonable deliveries that may be wanted. The United States Government will be a large buyer of war equipment of all kinds, as Congress has appropriated in excess of 700,000,000 dols. for all that enters into the conduct of war. Requirements from this source will compensate in a large degree for the inevitable termination of the European demand. It will be, of course, some time before any or much material will be wanted, but the demand will continue for years, as this step is preparatory.

Mining in Russia.—According to the report of the Werchlaset Mining Company, it appears that the copper industry of the Ural has been compelled to reduce its production on account of shortage of labour, of difficulties of transport, and owing to the impossibility of obtaining sufficient coke from the Donetz district. The cost of production has increased, but prices were fixed by a long-running contract with the Copper Syndicate, Medj. The Russian banks appear to be much interested in the Ural mining and metallurgical undertakings, and are by degrees acquiring a number of shares in these concerns. Thus the Union Bank of Moscow has acquired the majority of the shares in the Alepajew Metallurgical Works, which has a capital of 5,880,000 roubles. This is one of the oldest concerns in the Ural, and manufactures pig-iron and half-finished products.

Pile Protection against Wood-Borers.—The Common-Sense Pile Protector Company, Long Beach, California, according to *Engineering News*, New York, has put on the market a novel device for keeping tide water piles free from teredo, limnoria, or other wood-borers. The protector consists of a jointed metal ring, suspended about 16 in. below water level by floats attached at separate points. The protection is afforded by the combined scraping action of the wire, which surrounds the pile, and has a diameter about 1 in. greater than the largest diameter of the pile, and the pounding action against the pile of the floats attached to the ring. The floats are so attached that they revolve as arms, rubbing and continuously striking the pile, increasing at the same time the scraping action of the wire. A single protection will keep a pile clean from 2 ft. below low water to high water, and a system of multiple rings is available for complete protection from high water to ocean bottom. The protector is not sold or leased, but the company contracts to give the service of protection at a yearly rate per pile. It is stated that installations on the Pacific coast for the last four years have proved successful.

Victorian Land.—The area of Victoria is 56,245,760 acres, of which 24,009,440 acres have been alienated in fee simple, while 7,137,413 acres are in course of alienation. The Crown lands comprise 25,098,907 acres, viz., permanent forests, 3,064,916 acres; timber reserves, 752,145 acres; water reserves, 314,917 acres; reserves for agricultural colleges, &c., 85,107 acres; reserves in the mallee, 397,881 acres; other reserves, 303,860 acres; roads, 1,717,607 acres; water frontages, beds of rivers, lakes, &c., unsold land in cities, towns, and boroughs, 2,793,777 acres; grazing area leases, 2,747,571 acres; perpetual leases, 406,681 acres; other leases, 145.356 acres; temporary grazing licences, 9,985,392 acres; unoccupied, 2,383,697 acres. From the first settlement of the State to the close of 1913 the amount realised by the sale of Crown lands was 33,147,806*l*., representing an average of 1*l*. 1*s*. 3*d*. per acre. The payment of a considerable portion of the 33,147,806*l*. was extended over a series of years, without interest. The mallee country was named from the scrub found growing there; it occupies about 11,000,000 acres in the north-west portion of the State. The soil is light, and in its virgin state is covered with mallee scrub, with plains lightly timbered with box, oak and pine. Since the introduction of the mallee roller and the stump jump plough it has been possible to clear off the scrub at a moderate cost. With the extension of railway facilities and irrigation works settlement in this part of Victoria is rapidly extending.

NOTES FROM THE NORTH.

Glasgow, Wednesday.

Glasgow Pig-Iron Market.—Business in the pig-iron warrant market remains at a standstill, and while there has been a considerable reduction during the week of the stocks of pig-iron in store, that in Glasgow still keeps at 1,000 tons.

Scotch Steel Trade.—If there be any change to report in connection with the steel trade in the West of Scotland, briefly put, it is that the ever-increasing activity continues, the demands for steel for shell bars and for light section being particularly pressing, both for the home and the Allied Governments. Notwithstanding the enormous scale upon which these are being turned out, by mills running day and night unceasingly, the entire output is very speedily absorbed, and even with every possible effort being directed upon the work in hand, it seems impossible to avoid a certain amount of delay in delivery. The urgent necessity for war material of all grades has completely crushed out ordinary mercantile business, both for the home and the export trade, the Allies, to whom heavy shipments are being despatched, almost daily, being the only recognised overseas customers at the moment. In most of the steel and iron works the production of munitions of war is the pivot round which everything revolves, and although in establishments where certain repairs are at the moment an absolute necessity it has been deemed advisable to allow some workers a short period of rest to overtake these, any idea of a general holiday for those engaged on Government contracts cannot be entertained meantime. Any slacking off at the present would be highly detrimental to the ultimate success of our arms and those of our Allies, a fact which none perhaps realise more acutely than do those who are toiling night and day to supply the sinews of war. Firm prices still hold—ship-plates are now fully 15*l*. per ton; boiler-plates, 16*l*.; and angles from 14*l*. 2*s*. 6*d*. per ton and upwards.

Malleable-Iron Trade.—In the malleable-iron trade, as in practically every other branch of the iron and steel industry, the greatest activity continues to prevail, and makers and works managers are finding it increasingly difficult to cope with the orders forced upon them, for none need to look for business these days. War contracts are practically absorbing the entire output, to the complete exclusion of all mercantile and general business. Prices keep steady—"Crown" bars for home delivery are still quoted 14*l*. 12*s*. 6*d*. per ton, less 5 per cent., the better qualities realising a trifle more than this, while for export the rate is still about 14*l*. 2*s*. 6*d*. f.o.b. Glasgow.

Scotch Pig-Iron Trade.—The general condition of the Scotch pig-iron trade is much as it was a week ago, with both hematite and ordinary foundry grades in full demand. Hematite is undoubtedly becoming much scarcer, the local steel works still absorbing the bulk of the production, the remainder being shipped direct to one or other of the Allies. No material is available for any other purpose than that of the war, consequently licences are almost impossible to obtain unless for shipments to the Allies. On the other hand, all the available foundry iron is reserved for home consumption. Prices remain steady without any further advance.

War Workers and Holidays.—The Admiralty has now approved a scheme whereby workers in the Clyde shipbuilding yards and marine engineering shops may have a week's holiday, in order better to permit them to stand the strain of the long-continued and heavy pressure, which must continue for, probably, some considerable time yet. In Glasgow and Paisley a beginning will be made on Saturday of this week, each firm making such arrangements as shall be most suitable. This arrangement applies solely to the Clyde area, and only to shipbuilding yards and marine engine shops, all those doing munitions work being abjured by the recommendations of the Ministry of Munitions that they should continue at their posts until the end of September. In this way, and in this way only, will it be possible to maintain the required delivery of war material.

The Goldsmid Entrance Scholarship; University College, London.—The Goldsmid Engineering Entrance Scholarship, of the value of 30*l*. a year, tenable for three years, will be competed for at University College, London, in September. Full particulars of the scholarship examination can be obtained from the secretary of the college, to whom application should be made before September 1.

Cutlery.—Our exports of cutlery were well maintained for the first half of this year, the value of the shipments having been 303,812*l*., as compared with 258,640*l*. in the first half of 1915 and 380,203*l*. in the first half of 1914. The maintenance of this year's exports is rendered all the more satisfactory by the fact that shipments have of course ceased altogether to Germany, which, in the past, was rather a valuable customer. The United States imported British cutlery to June 30 to the value of 23,177*l*., as compared with 17,637*l*. in the corresponding period of 1915 and 37,917*l*. in the corresponding period of 1914. The most valuable external support of British cutlery is supplied by the colonial demand, which moved on as follows in the first halves of the last three years:—

Colonial Group.	1916. £	1915. £	1914. £
British South Africa ...	31,170	28,582	30,727
British India	30,413	31,994	44,228
Australia	97,086	75,694	79,410
New Zealand	22,042	15,257	14,535
Canada	31,452	25,770	37,194

A satisfactory feature in the colonial demand is that it has been scarcely at all affected by the war.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

South Yorkshire Coal Trade.—There are abundant supplies of all qualities of fuel on the market. Indeed, never before this year has there been so much free coal on offer. The main cause is an obvious tightening of the export restrictions so far as they govern the trade with neutrals. This has diverted increased supplies for home consumption, as the allied shipments, though heavy, are not sufficiently increased to absorb the coal released by the reduction of the neutral trade. Another and subsidiary cause is the periodical stoppages of the large Lancashire cotton mills for the holidays. This has somewhat disorganised the market, particularly for the smaller-sized coals. Local works and the railway companies are taking advantage of the excellent opportunities the present circumstances afford to lay in winter stocks, a privilege denied them for some considerable time owing to the brisk tone of the market and the scarcity of supplies. Gas companies are taking a large tonnage of their own special brands. There is not much activity with regard to house coal. Merchants have many orders on their books, but the retail trade at the depots is on the small side. Blast-furnace coke is becoming increasingly inquired for and meets a ready sale at current high rates. Quotations:—Best branch hand-picked, 20*s.* 6*d.* to 21*s.* 6*d.*; Barnsley best Silkstone, 17*s.* 6*d.* to 18*s.* 6*d.*; Derbyshire best brights, 17*s.* 6*d.* to 18*s.* 6*d.*; Derbyshire house, 16*s.* to 17*s.*; best large nuts, 15*s.* 6*d.* to 16*s.* 6*d.*; small nuts, 15*s.* to 16*s.*; Yorkshire hards, 16*s.* 6*d.* to 17*s.* 6*d.*; Derbyshire hards, 16*s.* to 17*s.*; best slacks, 12*s.* to 13*s.*; seconds, 10*s.* 6*d.* to 11*s.* 6*d.*; smalls, 8*s.* to 9*s.*

Iron and Steel.—It has now been established that the makers of common irons have the right to advance their prices 5*s.* all round on the original maxima, but Sheffield buyers are not finding the increase uniformly enforced. Some makers are demanding the full price, but others are accepting 90*s.* for foundry, and a proportionate reduction in the tariff for forge qualities. This is due to the quantity of material on the market at the present time. Foundry iron is meeting with a poor demand owing to a slackness in many of the works which absorb this particular make. It is stated in well-informed circles that there will shortly be a conversion of many foundry furnaces to basic for the purpose of enlarging the production of steel. Hematites are freely sought, and full prices have to be paid to ensure early delivery. The steel scrap market is disorganised by the Government prices maximum. The stipulation that material must be sold at no higher figure than 5*l.* 10*s.* operates in a very unfair manner, for it makes no allowance for variations in the quality of the scrap and the railway carriage, which must in many cases be a considerable item. Dealers here are not resting content with the position as it stands, but intend to press very strongly a few of the absurdities before the authorities. Now that the orders for cast-iron hand grenades have dwindled to a very small figure, the slackness in the stove-grate industry is more pronounced than ever. There has been little war trade for stove grates and builders' ironwork, but the contracts for grenades provided some small solatium, especially at the outset, when the orders were so substantial. To-day many of the stove-grate foundries are well-nigh idle. In view of this, it does not appear as if the workers have been particularly happy in selecting the present time for their application for a wages increase. They desire an advance of 6*s.*, plus the 4*s.* war bonus. As the masters do not see eye to eye with them on the subject, the Committee on Production will be called upon to decide the question. File-making is one of Sheffield's busiest industries, and hundreds of girls are employed in turning out the smaller sizes up to the 12-in. ones. The orders of the Russian Government, however, are themselves sufficient to swallow up the present output, and many manufacturers are somewhat in arrears with their contracts. Trade with France for every class of iron and steel manufactured in Sheffield grows apace. In July, France imported from this country many tons of steel, principally the finer brands, and Sheffield makers had a big share in that trade, which represented large sums. The new regulations of the French Government with regard to the importation of steel are, however, causing vexatious delays. One direct outcome will be an increase in clerical work, which manufacturers view with disfavour. From the export point of view, Sheffield attained a war record in July. This is particularly gratifying when note is taken of the multitude of difficulties and regulations manufacturers have had to contend with. The Colonies and South America have largely increased their business. The week's overseas mail has brought orders for cutlery, electro-plate, tools, machetes, saws, files and steel.

IRON ORE IN THE UNITED STATES.—The imports of iron ore into the United States for the year ended June, 1916, were 1,059,756 tons, as compared with 1,341,281 tons in 1914–15. Of the iron ore received from abroad in the ten months ended April, 1916, 63,610 tons came from Spain, 181,531 tons from Sweden, 84,343 tons from Cuba and 128,073 tons from other sources.

THE CRAMP COMPANY.—At the annual meeting of William Cramp Ship and Engine Building Company, Philadelphia, the net profits for the year ended April, 1916, were returned at 17½ per cent. on the capital stock, as compared with 10½ per cent. in 1914–15. Mr. H. S. Grove was re-elected president. In reporting upon the company's affairs, Mr. Grove said that it had unfilled contracts which would occupy all its building-ways during the present year.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

Business with Scotland.—The Control Committee having this week granted permission for sales of Cleveland pig-iron to Scotland for September, this has, not unexpectedly, brought in a number of inquiries from beyond the border, and the market, as a consequence, is more animated than it has been for some little time past. Apparently the policy of the Committee is to regulate trade with Scotland from time to time with a view to preventing more Cleveland iron going North of the Tweed than is actually needed for current requirements. Deliveries to Scotland over the next few weeks promise to be fairly good.

Cleveland Pig-Iron.—Apart from the demand from across the border the home trade shows little or no change. A few sales for near forward delivery are reported, but with supplies allocated by the Committee, nothing is to be gained by pressing for iron, and makers are not at all eager to sell. For home consumption, No. 3 Cleveland pig, No. 4 foundry, and No. 4 forge all stand at 87*s.* 6*d.*; and No. 1 is put at 91*s.* 6*d.* So far as export trade is concerned very little new can be reported. Sympathetic consideration is given to applications for licences to the Allies, and permits are granted as fully as circumstances will allow, but there is more and more difficulty experienced in securing licences for shipment to Scandinavia and other neutrals. A few sales to France and Italy and to the Far East are reported, but scarcity of tonnage as well as shortage of iron keeps shipments down. For export, No. 3 is 97*s.* 6*d.*; No. 4 foundry, 96*s.* 6*d.*; No. 4 forge, 95*s.* 6*d.*; and No. 1 in the neighbourhood of 102*s.* 6*d.*

Stocks of Cleveland Pig.—The stock of Cleveland pig-iron in the public warrant stores here has now been reduced to 19,553 tons, composed of 19,167 tons of No. 3 quality, and 386 tons of other kinds of iron deliverable as standard. So far this month the stock has been reduced by 4,247 tons, 4,263 tons of No. 3 having been withdrawn and 16 tons of standard iron having been added.

Hematite Iron.—Under direct official supervision, supplies of East Coast hematite are adequately maintained for Government purposes at home, and deliveries to our Allies are well upheld, but the pressure for supply to these quarters fully absorbs the output, and new business is hardly practicable. For home use and for shipment to France Nos. 1, 2 and 3 remain at 122*s.* 6*d.*, and for general export at 140*s.* and upward.

Shipments of Pig-Iron.—Shipments of pig-iron from the port of Middlesbrough are quite up to expectation. So far this month they amount to 27,449 tons, as compared with 27,214 tons to the same date last month, and 13,378 tons for the corresponding part of August last year.

Coke.—Supply of coke is more plentiful, but the surplus is small, and with demand very good, quotations are well maintained. Average blast-furnace kinds are 28*s.* at the ovens, and up to 30*s.* 6*d.* at the ovens is still asked for qualities low in phosphorus.

Foreign Ore.—There are no new features in foreign ore. Though buying is at a standstill, sellers show no signs of weakness, and quotations are unaltered. Consumers have large and steadily accumulating stocks, as heavy deliveries continue against running contracts. So far this month the imports to the Tees reach no less than 113,094 tons. With Rubio of 50 per cent. quality approaching 21*s.* f.o.b. Bilbao, and the freight from that port 19*s.* in the open market, the ex-ship Tees price should be in the neighbourhood of 40*s.*, but the recognised market quotation for best Rubio is 38*s.* ex-ship Tees, on the basis of the official 17*s.* freight Bilbao-Middlesbrough, the rate at which controlled consumers are privileged to arrange conveyance of the ore.

Manufactured Iron and Steel.—As regards finished iron and steel, Government work still fully occupies the attention of manufacturers, and little notice is taken of ordinary commercial inquiries. Quotations are stationary. Common iron bars are 13*l.* 15*s.*; best bars, 14*l.* 2*s.* 6*d.*; double best bars, 14*l.* 10*s.*; treble best bars, 14*l.* 17*s.* 6*d.*; iron ship-plates, 13*l.* 10*s.* to 14*l.* 10*s.*; iron ship angles, 13*l.* 15*s.*; iron ship rivets, 17*l.* 10*s.* to 18*l.* 10*s.*; packing iron and steel (parallel), 10*l.*; packing iron and steel (tapered), 12*l.* 5*s.*; steel bars (no test), 14*l.* 10*s.*; steel ship-plates, 11*l.* 10*s.*; steel ship angles, 11*l.* 2*s.* 6*d.*; steel ship rivets, 20*l.*; steel hoops, 16*l.* 10*s.*; steel strip, 17*l.*; steel joists, 11*l.* 2*s.* 6*d.*; heavy steel rails, 10*l.* 17*s.* 6*d.*; and steel railway sleepers, 12*l.*

AMERICAN PIG.—The steady progress which American pig-iron production had been making this year has sustained a check, the output for June having declined to 107,053 tons per day, as compared with 108,422 tons per day in May. The average daily production for the first six months of this year has been as follows:—January, 102,746 tons; February, 106,456 tons; March, 107,667 tons; April, 107,592 tons; May, 108,422 tons; and June, 107,053 tons. The monthly output for the first six months of this year compared as follows with the corresponding production in the first half of 1915:—

Month.	1916. Tons	1915. Tons
January	2,251,035	1,115,944
February	2,183,845	1,337,380
March	2,365,116	1,537,089
April	2,316,768	1,584,111
May	2,408,890	1,694,290
June	2,395,784	1,770,657

Of 394 American coke and anthracite furnaces, 323 were in blast at the close of June.

NOTES FROM THE SOUTH-WEST.

Cardiff.—There has been considerable pressure for steam coal in consequence of the heavy requirements of the authorities, which have left scarcely any better descriptions available for export. Until official requirements are relaxed there does not appear to be much probability of sellers having anything to offer beyond odd parcels. Tonnage has continued short for France, but steamers have been offering more freely for Mediterranean ports. Smalls have been firm, especially best bunkers. House coal, patent fuel and coke have shown scarcely any change. The best Admiralty large steam coal has been to some extent nominal; secondary qualities have made 38*s.* to 40*s.*; Monmouthshire Black Veins, 39*s.* 6*d.* to 40*s.*; ordinary Western Valleys, 39*s.* to 39*s.* 6*d.*; Eastern Valleys, 36*s.* to 38*s.*; best bunker smalls, 28*s.* to 30*s.*; and cargo smalls, 20*s.* to 22*s.* per ton. In bituminous coal best households have made 25*s.* 6*d.* to 26*s.* 6*d.* per ton at the pits; No. 3 Rhondda large, 37*s.* to 38*s.*; smalls, 29*s.* to 31*s.*; No. 2 Rhondda large, 32*s.* to 34*s.*; and No. 2 smalls, 22*s.* to 23*s.* per ton. The latest quotation for patent fuel has been 45*s.* to 50*s.* per ton. Special foundry coke for export has brought 62*s.* 6*d.* to 64*s.*; good foundry coke, 60*s.* to 62*s.* 6*d.*; and furnace coke, 50*s.* to 55*s.* per ton.

Western Trade Matters.—Insoles, Limited, gives its proprietors 20 per cent. for 1915–16. The whole of the company's debenture bonds were paid off July 1.—The Mumbles Railway and Pier Company has announced an interim dividend at the rate of 7½ per cent. per annum upon its ordinary shares.—The Swansea and Mumbles Railway Company has also announced an interim dividend upon its ordinary shares at the rate of 9½ per cent. per annum.—Mr. Eady Davies, miners' agent for the Ebbw Vale district, stated, on being recently interviewed, that upon the whole South Wales miners were patriotic, loyal and ready to make any sacrifice to bring the war to a successful conclusion; but there was a small section of men in the South Wales coalfield bent on defeating the objects of the leaders whenever an opportunity for doing so presented itself.—Judge O'Connor, who was appointed by Sir G. Askwith, of the Board of Trade, to arbitrate upon the percentage of increase to be awarded to South Wales steel workers upon the existing maximum, has decided upon an increase of 10½ per cent. in wages as from July 1.—The Powell Duffryn Steam Coal Company, Limited, has reduced the interim dividend upon its ordinary shares from 20 per cent. per annum to 18 per cent. per annum; the dividends, however, to be paid free of income-tax.—The Redcroft Steam Navigation Company announces an interim dividend and bonus of 20 per cent. for the half-year ended July 31; a similar distribution was made twelve months since.—Sir E. Haig presided at the annual meeting of the Hain Steamship Company, Limited, and showed that to meet coming competition we needed a large extension of merchant shipping; not only had we to make good considerable war losses, but we had also to provide for future maritime developments. Our very existence as a nation depended upon the maintenance of our supremacy at sea. It was proposed to pay a dividend of 2*l.* 10*s.* per share, or 30 per cent. for the year, carrying forward 5,635*l.* During the past year four of the company's steamers had been sunk by enemy submarines and two steamers and crews were still interned in Germany.—The directors of the Penarth Pontoon Slipway and Ship Repairing Company, Limited, announce an interim dividend of 3½ per cent. less income-tax; the corresponding interim dividend paid twelve months since was at the rate of 2½ per cent.—A report to the effect that the erection of steelworks is contemplated at Chepstow appears to be based upon the fact that inquiries have been made in the neighbourhood of Caldicot as to the suitability of old tin works at the Pill for an extension of the Standard Company's ship-building enterprise. The site, which is about 6 miles from Chepstow, has been reported upon favourably.—Proposals of the Government to shorten the supply of steel to tin-plate works have been received with serious forebodings in the Swansea district, as they may involve the closing of some tin-plate furnaces.—The 28th annual meeting of the International Coal Company, Cardiff, was held on Friday, Mr. Evan Owen presiding; a dividend and bonus of 15 per cent. were recommended, 5,500*l.* being added to the general reserve and 4,994*l.* being carried forward; it was stated that the company was suffering from a scarcity of labour, in consequence of many of its men having joined the forces.—The Port Talbot Railway and Docks Company has announced a dividend at the rate of 9 per cent. per annum upon its ordinary capital.—A meeting of the Cardiff Shipowners' Association was held on Friday, when there was a discussion as to freight rates to be fixed for the French ports of Duclair, Morlaix, Gravelines, Marans, Sables, Arcachon, L'Orient, Tonnay, Charente and Hauzebout. It was agreed to fix the rates at levels proportionate to a schedule.—The directors of the Fernhill Collieries, Limited, recommend a dividend of 20 per cent. on the ordinary shares for the year ended June 30; the corresponding dividend for 1914–15 was 16 per cent.; and for 1913–14, 10 per cent.—The Ashburnham Colliery Company has acquired the Cwm Capel Colliery.—Canadian trade Commissioners visited Bristol on Monday for the purpose of collecting information as to Bristol-Canadian trade developments; the Commissioners left for Birmingham on Wednesday.

CARGO SHIP REPAIR WORK.—The largest repair of a steamer hitherto undertaken in Scandinavia is that of the Fridland, a Swedish boat which, in May, struck a mine in the Channel and was run aground in the Thames. After a provisional repair she was able to proceed to Malmö by her own engines.

TURBO-COMPRESSOR FOR A MIDLANDS COLLIERY.

CONSTRUCTED BY THE BRITISH THOMSON-HOUSTON COMPANY, LIMITED, ENGINEERS, RUGBY.

(*For Description, see Page* 152.)

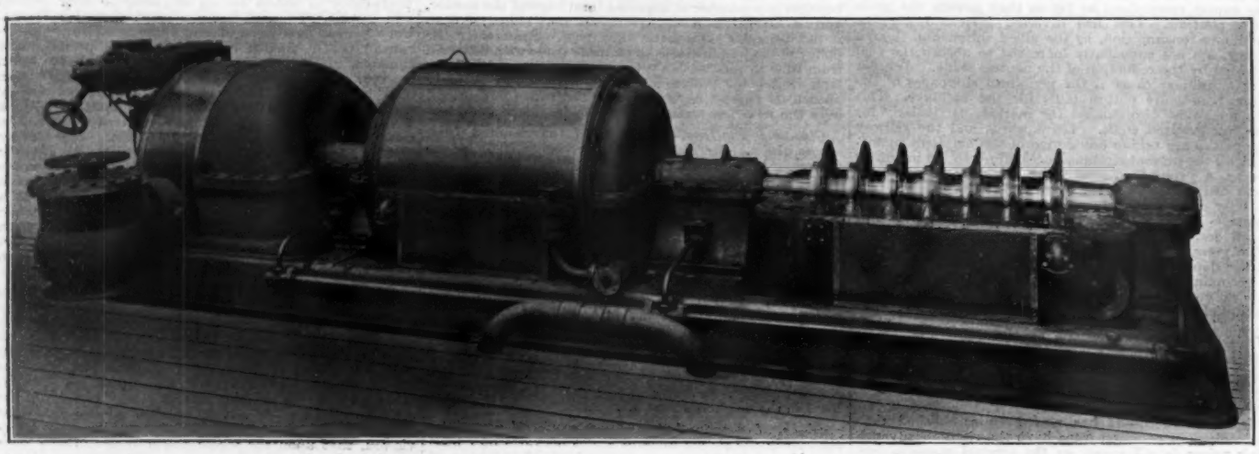


Fig. 1. General View of Compressor.

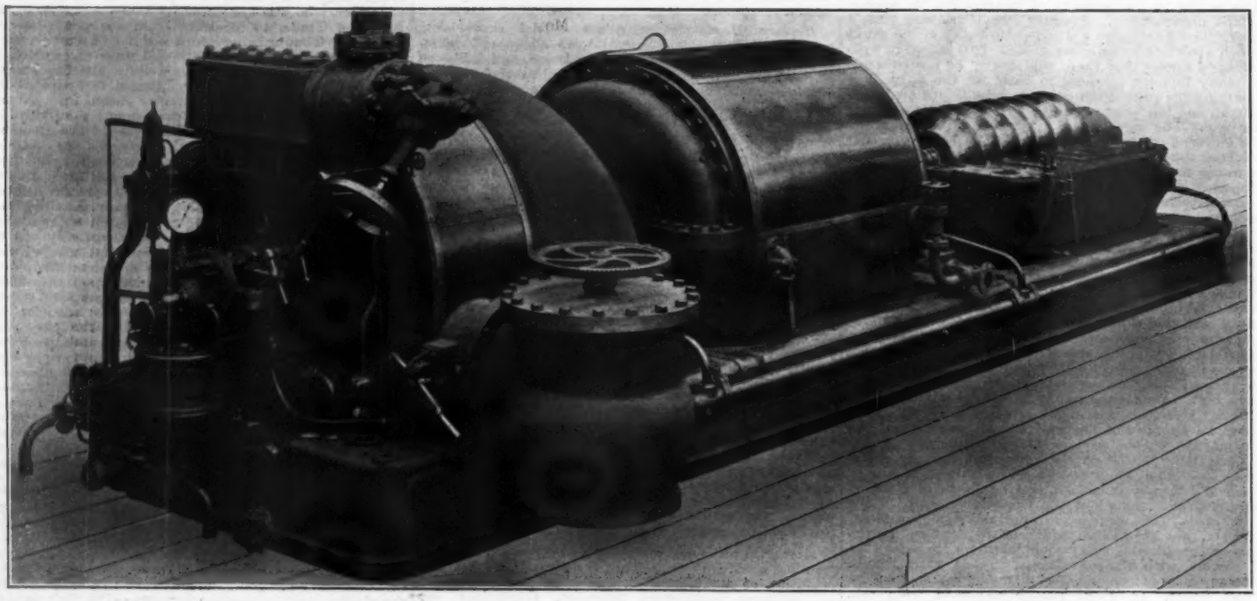


Fig. 2. View Showing Steam End of Compressor.

Fig. 3. View Showing Construction of Impeller.

BOILER FOR LOCOMOTIVES, CLASSES "K4S" AND "L1S;" PENNSYLVANIA RAILROAD.

MR. J. T. WALLIS, GENERAL SUPERINTENDENT OF MOTIVE POWER.

(*For Description, see Page* 147.)

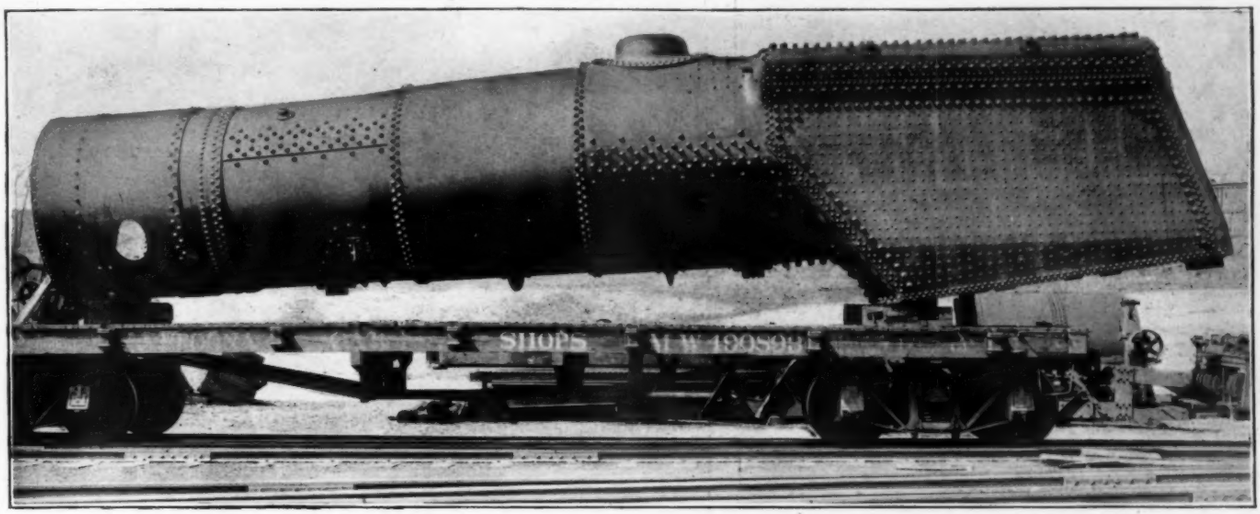
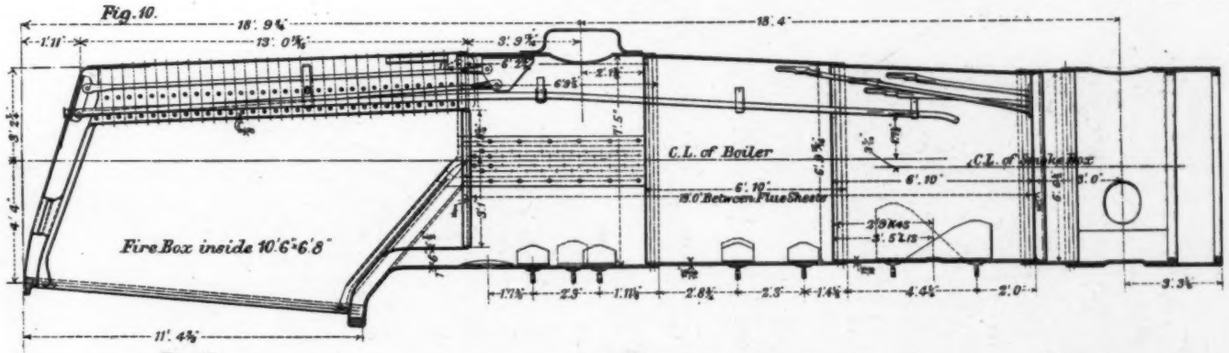
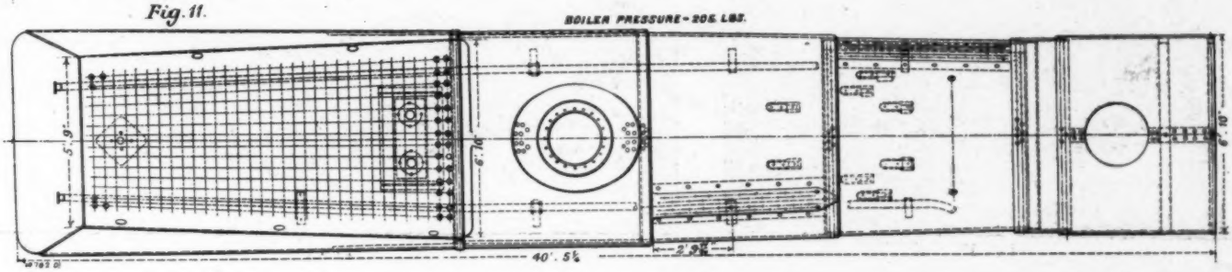
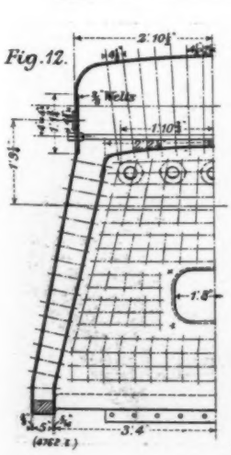
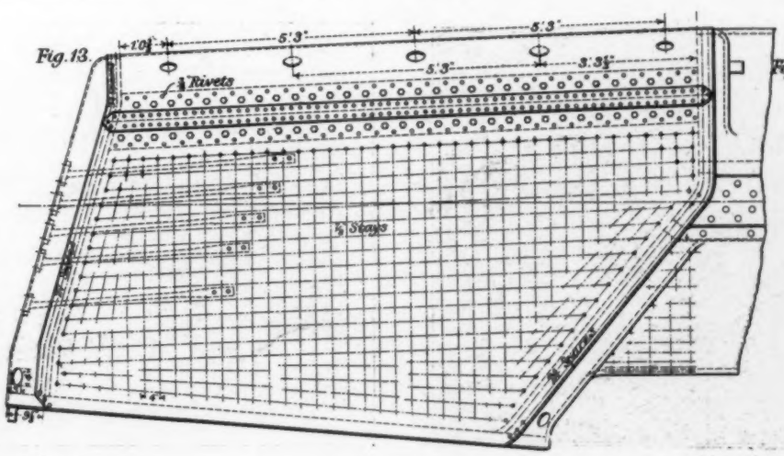


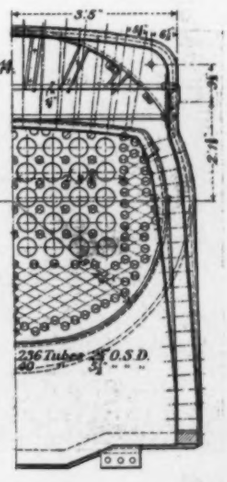
FIG. 9.











(*To face page* 146.)

BOILER FOR LOCOMOTIVES, CLASSES "K4S" AND "L1S;" PENNSYLVANIA RAILROAD.

MR. J. T. WALLIS, GENERAL SUPERINTENDENT OF MOTIVE POWER.

(*For Description, see Page* 147.)

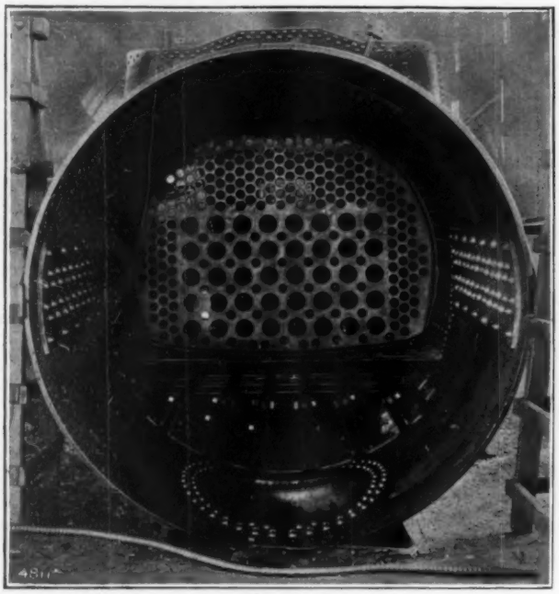
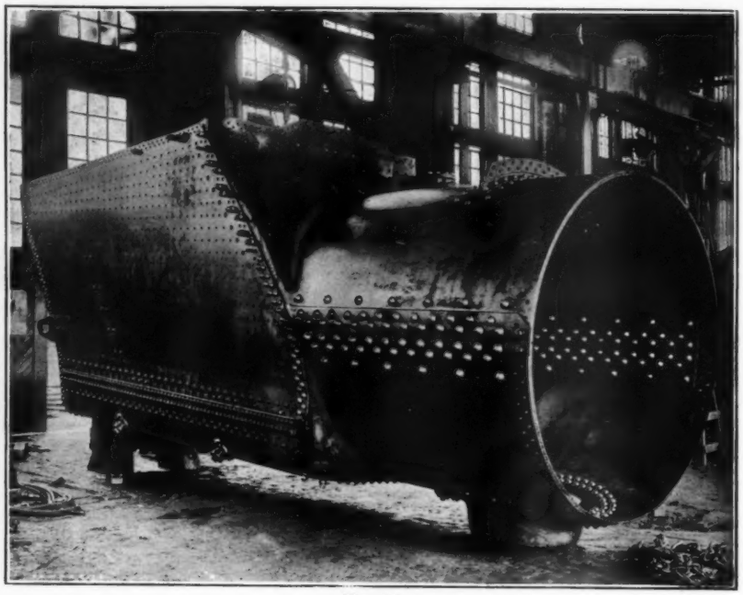


FIG. 15.



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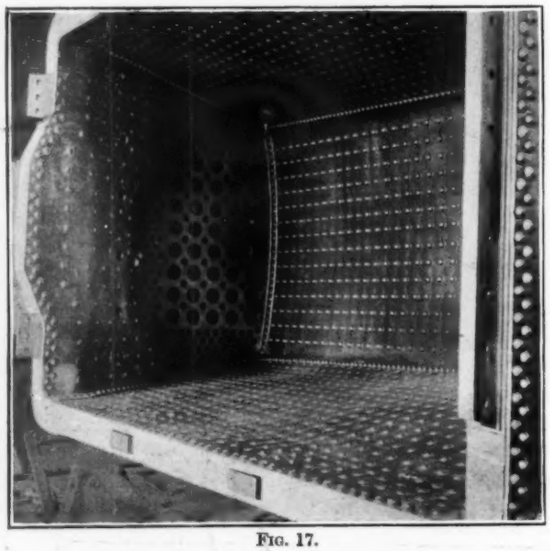

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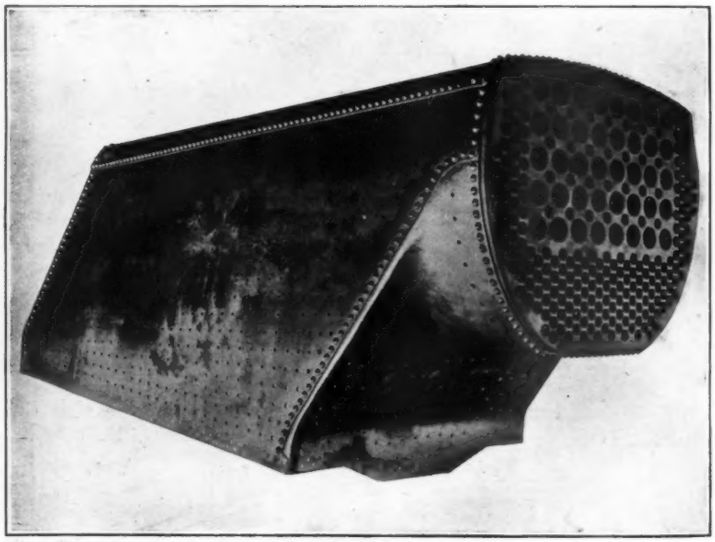

FIG. 18.

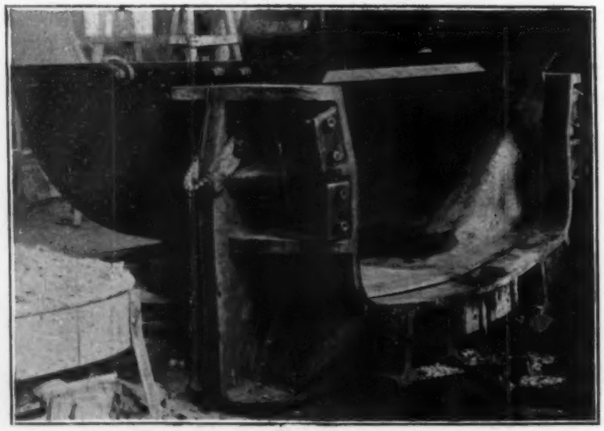

FIG. 19.

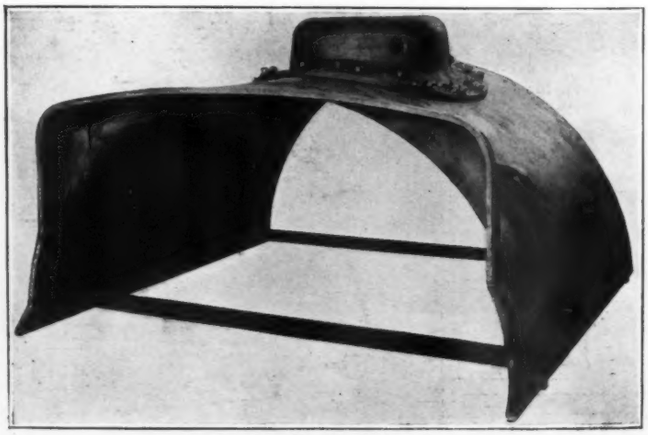

FIG. 20.

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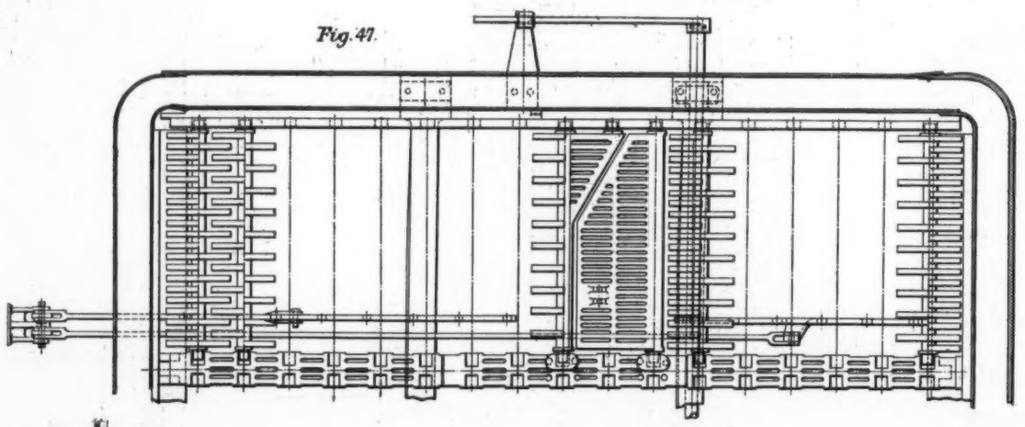
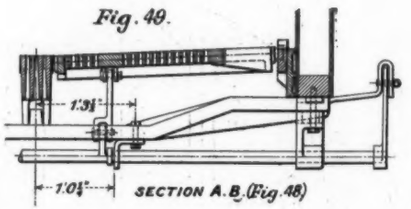
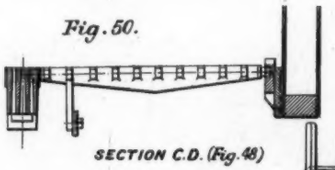
DETAILS OF BOILER FOR LOCOMOTIVES, CLASSES "K4S" AND "L1S;" PENNSYLVANIA RAILROAD.

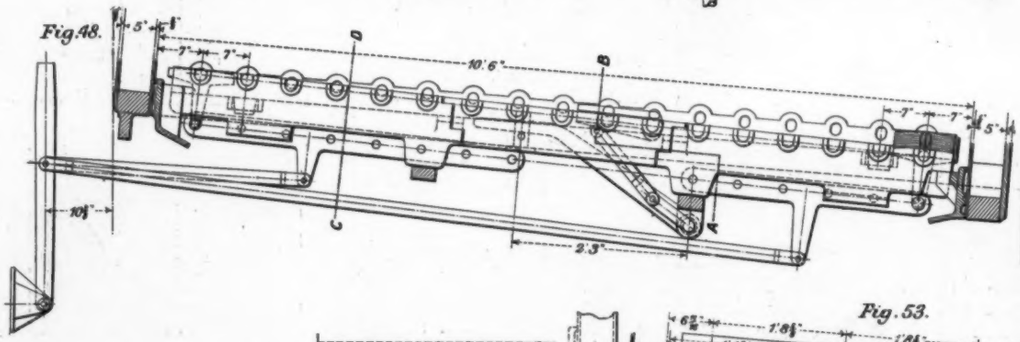
MR. J. T. WALLIS, GENERAL SUPERINTENDENT OF MOTIVE POWER.

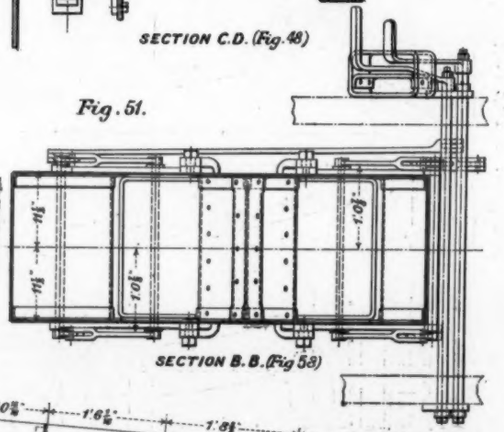
(*For Description, see Page* 147.)

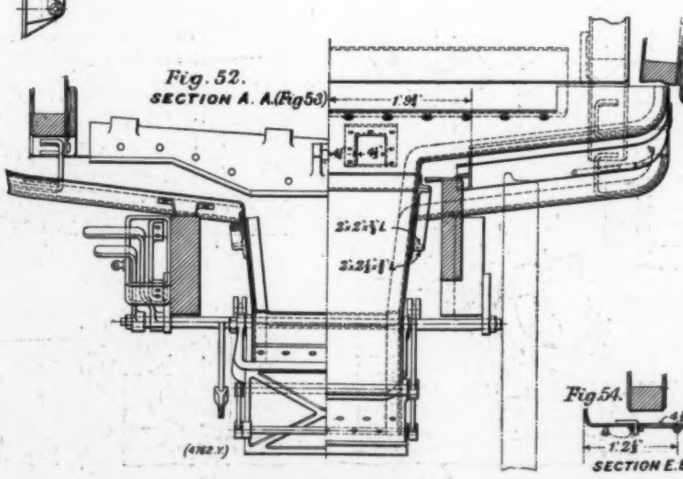


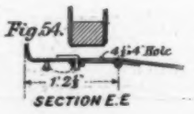


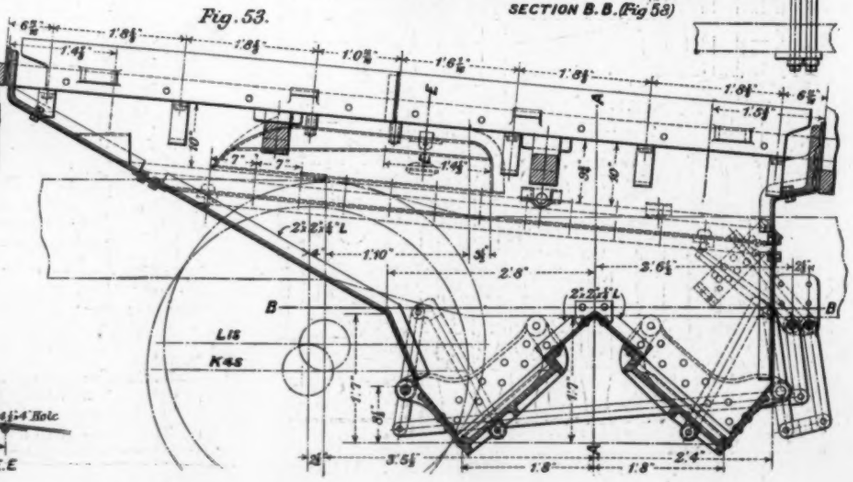












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DETAILS OF BOILER FOR LOCOMOTIVES, CLASSES "K4S" AND "L1S;" PENNSYLVANIA RAILROAD.

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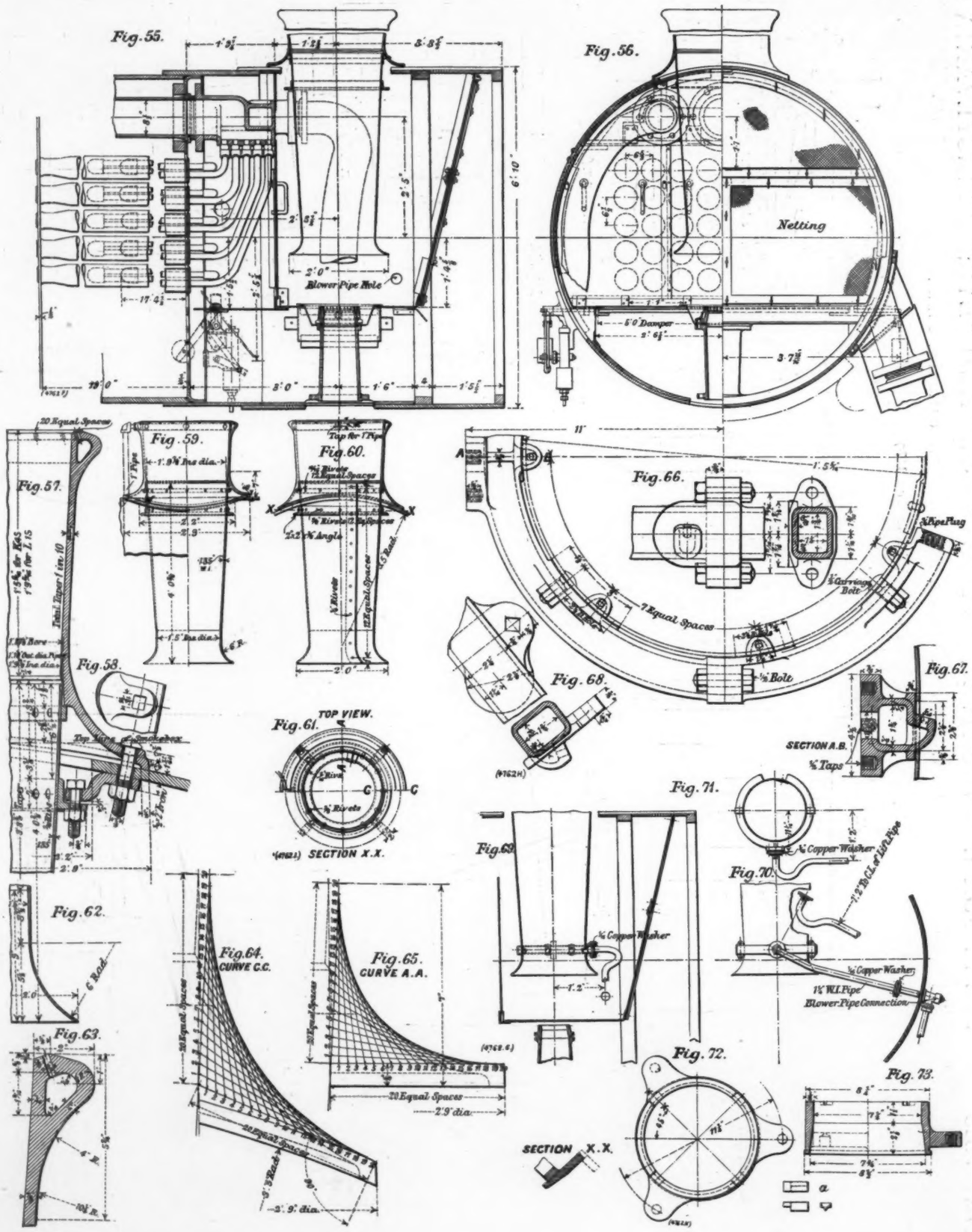

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Advertisements intended for insertion in the current week's issue must be delivered not later than 5 p.m. on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received not later than 1 p.m. on Tuesday in each week.

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We desire to call the attention of our readers to the fact that the above is our SOLE ADDRESS, and that no connection exists between this Journal and any other publications bearing somewhat similar titles.

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TELEPHONE NUMBERS—3668 and 8568 GERRARD.

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With Four One-Page Plates of BOILER FOR LOCOMOTIVES, CLASSES "K4S" AND "L1S," PENNSYLVANIA RAILROAD.

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions now imposed by the Government on the importation of paper, and of the consequent shortage of supplies, readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk. Owing to the scarcity of paper it will be impossible in future fully to provide for a chance demand for this Journal.

ENGINEERING.

FRIDAY, AUGUST 18, 1916.

MUNITIONS.

OBSERVERS from the Front give evidence that Germany in her system of military training has adopted whole-heartedly the opinions of Xerxes as recorded by Herodotus. "If men," said Xerxes, "are placed under an absolute master, then, inspired by dread of him, they will display a valour which nature has not given them, and if soundly flogged may even advance, but abandoned to liberty they will do nothing of the sort." The event did not justify his confidence, and the personal superiority of our own men, who are *led* by their officers, over the "cannon fodder" which was "driven" against them for so many months, is conclusively demonstrated by the way their ground was held in spite of a flagrant inferiority in almost every detail of armament and equipment.

A due appreciation of this is essential to any adequate realisation of the true significance of the speeches delivered in the House of Commons on Tuesday evening last by Mr. Montagu and Mr. Lloyd George.

The latter observed that the House would be simply appalled to hear of the dangers we had run last year through shortage of munitions, and expressed his relief at the failure of the Germans to seize the chances they then had and which can never recur. "Fortune," says Bacon, "turneth a bald noddle after she hath presented her locks in front and no hold taken," and Mr. Montagu's statement shows that whatever the future effort of the Hun, he can never hope to re-establish the staggering superiority in armament and munitions which he was able to exploit during the first eighteen months of the war.

Before the war, we had three national factories employed in supplying our military needs. Now there are 95, of which 18, erected during the last twelve months, are engaged in filling gun and trench mortar ammunition. Of these one alone is filling nearly twice as much as Woolwich. We are now, moreover, producing in four days as many heavy shells as were turned out in the whole of 1914–15, and the maximum is still far from being attained, since in the case of the 12 national factories engaged on this class of work the present output is less than one-half of the ultimate capacity. Nevertheless, the supply during the past strenuous weeks has been equal to the expenditure, and before long will suffice for an equal rate along the whole of the front we hold. It was, of course, in the provision of heavy ordnance that the prescience of our advisers proved most in defect. Indeed, Mr. Lloyd George ventured on his own initiative to order many more of these weapons than the military experts thought necessary at the time probably on the sound basis that a surplus could at any rate be used by our Allies if not required by ourselves; but requisitions since made have shown that far more are required than were covered even in his enhanced estimate. We shall therefore have no real surplus before the spring of next year, although we are now producing per month as many such guns as we had actually in service twelve months ago.

Of medium-sized shell, we now produce in 11 days as much as in the whole year 1914–15, the corresponding figures for field howitzer shells and for 18-pounder shells being two weeks and three weeks respectively. In the case of bombs the output has been increased thirty-three fold. It further appears that we are rapidly becoming independent of supplies from the United States, and though a few months back 70 per cent. of our shell bodies came from America, we are now able to supply all the light bodies, and with the assistance of Canada it is expected that the same will soon be the case with heavy shells. It is of interest to note that our supply of field guns is now considered adequate. The conditions as to machine guns is almost as satisfactory, and it is expected that in a few months' time we shall have a surplus available for our Allies. Three times as many rifles have been turned out during the present year as in the whole of 1914, and we note that the whole of these and of the machine guns have been made in this country.

In awarding credit for the changed state of affairs Mr. Montagu seemed inclined to give to organised labour a credit substantially in excess of its due. In considering this matter it has to be borne in mind that the whole future of democracy was at stake, and that the success of the Central Powers would have firmly established the aristocratic and autocratic ideal. Under these conditions the behaviour of labour in South Wales, on the Clyde, and on the Tyne has in certain respects undoubtedly fallen far below the standard which would justify Mr. Montagu's encomiums. On the other hand, Sheffield has worked splendidly, and good reports have been received from the Midlands and from the Metropolitan area. Mr. Montagu, in fact, endorsed the whole of the most extravagant claims yet made by labour representatives. Who would imagine from his language that the "cherished principles held necessary to secure a proper recompense" for labour included the consistent restriction of output and insistence on the employment of highly-skilled labour on unskilled work.

It is, however, only fair to recognise that resistance to dilution was not confined to the men, but certain employers also felt reluctant to impart to possible future competitors the exceedingly valuable results of their dearly-bought experience. For this reluctance the authorities are no doubt largely themselves responsible. In France, when it was desired some years ago to widen the field for the supply of destroyers, contractors were instructed to include in their tenders a fee of 10 per cent. for the benefit of M. Normand's drawings and experience. Here the plan adopted was to distribute amongst all likely firms complete copies of the working drawings of boats built for the Government by leading firms and to their own designs. Copyright in his plans is as due to the engineer as to the architect, or to the author in his books.

In spite of such experiences, however, most of our leading firms have responded nobly and made dilution possible by providing the "know how" and organisation, a lack of which would have increased out of all reason not only the money costs, but by the consequent delays in delivery have led to an appalling strain on the defensive powers of our troops at the Front. No adequate recognition of these services is to be found in Mr. Montagu's speech, though he does give credit to our armament firms for the excellence of the designs of our new heavy guns, which outrange those of the Germans, and have received the highest commendation from General Gossot, the technical chief of the French Ministry of Munitions.

Very warm praise is awarded by Mr. Montagu to the Enfield Small Arms Factory, and it may be deserved, but is somewhat discounted by a statement made later with respect to the manufacture of high explosives. Mr. Montagu observed that the production of high explosives is sixty-six times as large as at the beginning of 1915, by far the most of it being, he asserted, produced in Government factories. Technically, no doubt, this statement is accurate. Official statements, even when intended to mislead, generally manage to achieve this virtue, but Mr. Montagu gives no information as to how these factories have been started and staffed. To say the least, much assistance was obtained from non-official sources. One of our leading civil engineers was, we know as a fact, responsible for the construction of several, and for months at any rate worked without fee or reward, not receiving even the whole of his out-of-pocket expenses. One large firm of manufacturing chemists, again, put at the service of the Ministry their ablest chemists, whose discovery and selection has been the work of years. No doubt other firms have acted similarly, but one looks in vain for any recognition of these services in Mr. Montagu's speech.

It would not, indeed, be going too far to assert

that the success of the Munitions Ministry has been almost wholly attributable to the private firms and to non-official chemists and engineers. One chief of a munition works only overcame official procrastination by the ironical inquiry, "Gentlemen, do you happen to know that there is a war on?" Another engineer at the head of an important committee has stated that for long he felt that he was purposely obstructed by the officials, but gradually came to realise that the whole trouble was the traditional reluctance of the class to accept individual responsibility. It is, no doubt, the results of the same tradition that led another engineer responsible for the output of many thousands of heavy shells per week to declare that the sole chance of winning the war would be the destruction of Woolwich and all that belonged to it by Zeppelins.

"Theirs not to reason why" may be an excellent maxim for the services, but the able and energetic men who are working 12 to 14 hours a day in the endeavour "to deliver the goods" cannot contentedly accept apparently unreasonable requirements of specifications involving in some cases a reduction of 20 per cent. in the output. Good reasons may exist for the demands made, but men of the class in question are not to be fobbed off with the absurdities which may suffice to silence the untrained journalist or political head of a department.

In a certain factory making large shells an official complained that the machined surfaces were not highly finished. Possibly it soothes the feelings of a Bosche to be laid out with a highly polished piece of metal; but this seems no adequate reason for the reduction of output which would be entailed by yielding to the sample. The official in question attributed the lack of finish to the fact that the men were accustomed to work in inches instead of in millimetres. As a matter of fact, the machinists engaged here were practically as unfamiliar with inches as with millimetres, being for the most part unskilled labourers. Their output has, however, been astonishing. Returns prepared for the Inland Revenue authorities show that certain of them have been earning from 100*l.* to 120*l.* in the quarter, a common figure being between 60*l.* and 70*l.* Of course the machines have suffered, and only those of the strongest design and material have been able to withstand the treatment. In fact makers have been told that the ideal to which they should strive to attain is to make the bed the weakest part of the machine, and to make this bed as strong as the strongest yet built. British lathes have for this work proved far superior to those imported from the States, even when these have been sold by their makers as designed for heavy duty. Served by skilled men, no doubt they would have shown up better, since it is impossible for a mechanic even wantonly to maltreat a machine as violently as an untrained labourer may do in pure ignorance. In spite of this ignorance, however, these employees have, as will be evident from the figures of earnings just quoted, attained an astonishing output, and they will no doubt have taught our machine builders a lesson from which the benefit will be reaped in future years.

Mr. Montagu referred to the difficulty found in obtaining an adequate corps of inspectors, and many are the complaints made on this head by manufacturers. In some cases it would seem that the departments have attempted to compensate for a lack of adequate technical training on the part of the inspectors by specifying absurdly close limits of dimensions for certain components. Any one of fair intelligence may be taught to apply a gauge, although years of experience may be necessary to produce a man really capable of distinguishing good work from bad.

Certain inspectors, moreover, conceive that they prove their vigilance by rejecting a fixed percentage of all stuff submitted. Shells, for example, were being constantly rejected for loose base plates, and, suspecting the reason, the firm concerned sent through a batch with no base plates at all, and of these, as before, a certain percentage were marked as having loose plates. In another case the sample shell supplied as a model was put through in order to test the inspector, and was rejected by him. On the other hand, we have not heard in engineering works of cases of blackmailing by inspectors, such as have been reported elsewhere, but the incidents we have noted above greatly increase the strain on the factory managers, who, as a class, are doing their utmost for the nation, and in many cases for a remuneration actually less than that of some of the unskilled hands who run the machines.

All will join in Mr. Montagu's tribute to Mr. Lloyd George. Amongst politicians he has an almost unique record for venturing to tell unpalatable truths to his own supporters, and amongst administrators he has the equally rare distinction of seeking advice and assistance not merely from official sources, but from any competent authority. Both qualities have been invaluable. No small portion of the resistance of the workmen to dilution was due to the absurd suppression and distortion of disquieting facts by certain popular journals and politicians, and had the supply of munitions been left in the hands of the permanent officials, Germany would have gone far to achieve her ambitions. Mr. Lloyd George realised that there was greater knowledge and capacity outside of the departments than within them, and acting on this conclusion has perhaps contributed more than any single individual to our ultimate success.

RUSSIA'S NEW OPEN PORT IN THE NORTHERN SEAS.

So many inaccurate and incomplete statements have been made in connection with the Murman Railway, from Petrograd to Russia's new open port in the Northern Seas, that it may be of interest to learn the actual state of the undertaking, as communicated to a Norwegian newspaper by Mr. I. Lied, the director of a large Russo-Norwegian shipping and trading concern, who has means of knowing the conditions of the railway.

The Murman Railway, which really may be said to commence at Petrograd, is divided into five sections:—

1. Petrograd–Zwanka, 114 versts (76 miles) (old railway).
2. Zwanka–Petrosavodsk, 256 versts (170 miles), new railway, completed.
3. Petrosavodsk–Kern, 408 versts (271 miles), new railway, completed.
4. Kern–Kandalakscha, 322 versts (215 miles), new, in course of construction.
5. Kandalakscha–Murman Port, 265 versts (177 miles), new railway, completed.

Altogether 1,365 versts (910 miles).

Section 1 is a part of the State north railway system to the Ural. Section 2 is the new private, so-called, Olonetskaja Railway, built with a view to the Murman traffic. This section is entirely finished, as is also Section 5, while Section 3, some 80 versts south of Kern, although not quite ready, is expected to become so in a few weeks, or may, in fact, already be fully finished. Section 4 is the only portion of the railway not yet practically completed, but there is every reason to believe that it will be ready about the end of the present year, when the whole line, Petrograd–Murman, consequently should be opened to traffic.

Murman Port, the terminus at Kola, lies 10 versts to the north of the small town of Kola, and thanks to the Gulf stream, it is never closed by ice. So far there have been constructed wooden quays for three large steamers, and a crane of 25 tons capacity has been installed. The inner port is spacious and well protected, and more than 40 good-sized boats have been anchored there at the same time. Besides, Kola Bay itself makes an excellent harbour, from 1,200 to 3,600 yards broad, with a depth of water of 70 ft. The greatest difference between high and low water is 13 ft., with comparatively little current. At low water the depth at the quays is 30 ft.

In spite of all conflicting reports the Murman Railway should be ready for general traffic at the beginning of next year, and it is difficult to overestimate the importance of this event. No country in the world with such possibilities as Russia is so unfavourably situated as regards outlets to the sea. Archangel and the other northern outlets are icebound a considerable part of the year; the same applies more or less to Russia's ports on the Baltic. The Dardanelles are not under Russia's control, and Vladivostok has thus been the only ice-free port at the disposal of Russia throughout the year. But Vladivostok is 6,000 miles distant from Petrograd. No wonder that the approaching completion of the Murman Railway is hailed with a feeling of relief and great satisfaction throughout Russia.

The building of the Murman Railway is a feat second only to that of the Siberian Railway, more especially in view of the rapidity with which the work has been pushed ahead under unfavourable circumstances. The length of the railway is not so tremendous, being 834 miles new line, but it passes through districts offering very serious and varied difficulties. To begin with, there were no roads along which men and materials could be conveyed to the places where they were wanted. Everything had to be transported over long distances at a heavy cost. In some places the track ran through granite deposits, and in others through heavily timbered primæval forests. More difficult than either were the great lengths of boggy country which had to be crossed. Over hundreds of miles the railway had to be built on piles. There has also been a great deal of trouble with labour and engineers; many foreign contractors sent both engineers and men to the railway from distant parts, but they often left again, so that the Russian Government had to take up the work. Swarms of insects also tended to make the work difficult during the summer months, but all the troubles and obstacles have now been overcome.

PETROLEUM CRACKING FOR GASOLINE AND BENZENE-TOLUENE.

Three years ago an Imperial Motor Transport Conference deliberated in London* on means of meeting the threatening dearth of motor fuels. A year later the war broke out. A year is a short time for creating or developing an industry. The representatives of all divisions of the Empire had practically agreed that alcohol could be substituted for petrol; but little was done in that year to provide for the alcohol. In 1913 this country consumed about 100,000,000 gallons of motor fuel for the 440,000 motor vehicles in use by the end of the year. What the figures may be to-day, one can only imagine. Most of that fuel has to be imported, and is derived from natural oil; and the United States, which supply 65 per cent. of the world's demand in crude petroleum, are seriously considering a restriction of these exports, and especially of the much higher percentage of refinable crudes. Together with Russia and Mexico the United States produce 90 per cent. of the world's natural oil, but Russia and Mexico furnish little motor fuel. In the year 1910 the United States exported 77,650,923 gallons of gasoline and naphtha; by 1912 the figures had more than doubled; in the year ended June, 1915, they had risen to 244,546,872 gallons. Ordinary oil refining furnishes little gasoline and naphtha. To produce 3,000,000 barrels of gasoline by the Burton process the Standard Oil Company "cracked" in that year 18,000,000 barrels of oil. That means that only one-sixth of the bulk of the paraffin-base petroleum was converted by the most efficient cracking process in use. All such processes involve a great deal of waste, which a country cannot tolerate when its resources are being drawn upon at an amazingly increasing rate. The total production of gasoline in the United States was 41,600,000 barrels in 1915, against 6,920,000 barrels in 1904; 6,500,000 barrels were exported in 1915, leaving 35,100,000 barrels for consumption in the country. As elsewhere, the demand for motor fuel in America was far outstripping that for lamp oils and other purposes. No wonder the International Association of Recognised Automobile Clubs recently offered a prize of 100,000 dols. for a gasoline substitute.

It is satisfactory to learn that cracking has been decidedly advanced in two directions by the United States Bureau of Mines, a national institute which more and more attracts international attention. The investigators of the Bureau have been able to establish two important facts: firstly, all oils, even the asphaltic Mexican oils, can successfully be cracked; and, secondly, they can be cracked not for gasoline only, which was recognised, but also for

* See Engineering, vol. xcvi., page 124; July 25, 1913.

benzene and toluene, which was hardly recognised, though the experiments of Veith and Letny on the production of aromatic bodies from petroleum residue go back to 1862. The report on the investigations* is very interesting, moreover, in another respect. The laboratory experiments by Dr. W. F. Rittman, Chemical Engineer to the Bureau of Mines, and his staff, were succeeded by commercial-scale experiments conducted by the Bureau in conjunction with the Aetna Explosives Company, of New York, under a special agreement with the Department of the Interior as Trustee concerning licence and rights of publications and patents, and by February this year seven gasoline refineries were installed in six States, and the company mentioned had started to make benzene and toluene by the new process. We have already noticed the work done by the Bureau and others in this field on recent occasions,† and we will now deal more with general features and the latest developments. The *Bulletin* contains a great deal of instructive information on the theory and chemistry of the reactions, describes and illustrates the apparatus and experiments, and reviews the literature.

That the many constituents of petroleum would, under the influence of heat and pressure, undergo a certain modification—in general a dissociation of complex molecules into simpler molecules without being totally decomposed—had been known for more than half a century. J. Hirsch noticed in 1868 already that all commercial petroleum distillation was accompanied by a certain amount of cracking, and Engler and Höfer pointed out later that distillation, even below 200 deg. C. at ordinary pressure, was not possible without some decomposition, whilst cracking is not supposed to set in below 325 deg. C. The original cracking aimed at producing illuminants from lubricants and lighter oils, and it was soon discovered that high temperature and pressure were generally favourable and hastened the conversion, but that they also favoured the formation of hydrogen, methane and other gases, not desirable and not condensable at ordinary temperature—hence called permanent by Rittman, though the simple distinction between gases and vapours would appear preferable—and, further, of carbon as coke, soot or tar. These products mean serious waste, and the coke incrustation in particular causes much trouble. The use of high temperatures and pressures with large volumes of liquids in the presence of vapours further involves grave danger. Many inventors therefore worked at atmospheric pressure, by passing the gases from the still through a superheater, by placing a pressure-reducing valve between the still and condenser, and by other means; but at low pressure (unsaturated) olefins (not gasoline) were the chief product, and the modern tendency favours cracking in tubes or pipes instead of in stills or large retorts. To facilitate the reactions, hydrogen and steam (which, dissociating, yields hydrogen) and also catalysts are introduced into the still or tube; the superheated steam also sprays the heavy oils, and the catalyst (*e.g.*, electrically heated platinum) causes the unsaturated hydrocarbons to take up hydrogen.

In most of these experiments and proposals the vaporised oils are passed through cracking tubes. The only process in extensive use in the United States, however, that of the Standard Oil Company (W. M. Burton and R. E. Humphreys), works with stills. According to the *Bulletin* the process is limited to petroleum distillates with a boiling-point of 500 deg. F. (260 deg. C.) or above, the initial material being subjected in the still to temperatures between 650 and 800 deg. F. (343 to 426 deg. C.) at a pressure of 4 or 5 atmospheres; the vapours are condensed under pressure in a condenser of ordinary type, inclined pipes, 12 in. diameter, 40 ft. long, returning the heavier condensed oil to the still. The McAfee process of the Gulf Refining Company also makes use of a still, into which aluminium chloride is introduced to act as a condensing medium for gasoline, so that the cracking can take place at the relatively low temperature of 500 deg. F.

There are other important considerations. In all two-phase (liquid-vapour) systems pressure and temperature rise together and cannot be controlled independently, unless one phase is caused to disappear. When the reactions all take place in the vapour phase, temperature and pressure can independently be altered and be raised in comparatively simple apparatus without incurring the great risk of high temperature and pressure reactions of two-phase systems. The speed of the reaction can, moreover, be observed, and the equilibrium-conditions are simpler, though still sufficiently complex with so complex a material as petroleum. As a rule pressure favours any reaction resulting in a decrease of volume and opposes any reaction that is accompanied by an increase of volume. Whether indications of the effect of pressure can, in the case of petroleum, really be obtained simply by writing down an equation and summing up the volume changes, as the *Bulletin* proposes, looks doubtful, however. In general it may be said that the higher the temperature, the more non-condensable gas will be produced and that in a certain sense the reactions tend to equilibrium conditions. Thus in the presence of an excess of hydrogen, further hydrogen is not split off from the oils; this was shown by Hempel and is confirmed by Rittman. On the other hand reduced pressure (not high pressure) might be thought advantageous, because it favours the dissociation of complex compounds of high molecular weight, whilst as a matter of fact, diminished pressure in cracking favours the liberation of gas, and the building up of the gasoline molecules requires high pressure. One feature must not be overlooked. To work in the gaseous phase, the liquid has first to be vaporised, and that means that higher temperatures may initially have to be applied to secure efficient evaporation than are wanted for the reactions. In this respect the vertical tube is preferable to the still; the material is admitted from above in drops, and the non-vaporised portion falls down the tube, and is removed from the zone of reaction. As regards uniform heating and carbon formation, the tube certainly appears superior to the still, though the carbon trouble remains serious even in tubes, when the carbon is deposited, not as soot or tar, but as hard coke.

The experiments by the Bureau of Mines were conducted in the Department of Chemical Engineering of Columbia University, New York, with the assistance of Professor M. C. Whitaker and the staff of that college. The five oils used represented widely differing types: a water-white Pennsylvania kerosene (paraffin base), Oklahoma residuum (mixed base), California Kern River crude (asphaltic base), Mexican crude and Russian residuum. The cracking ranges were 950 to 400 deg. C., and pressures of $\frac{1}{10}$ to 30 atmospheres. The cracking tube was a vertical wrought-iron tube, 1½ in. diameter, 32 in. long, wound over a length of 18 in. with nichrome wire. In the upper portion of the tube was a perforated plate supporting steel balls; the oil fell from a sight-feed drip cup on the hot balls, and to allow the oil to enter the tube at all pressures, a pipe connected the cup and the furnace. The tube was continued below in a vertical condenser, which was connected with a drop-bottle and with a gasometer, a pump being branched off the latter connections. The chief object was to ascertain the favourable and unfavourable conditions for the formation of both gasoline and aromatic hydrocarbons (benzene-toluene, &c.). With the small amounts of oil used (1 or 2 lb. per experiment) quantitative analysis of the very complex products—always difficult—would have been impossible; hence such indications as density, viscosity and refractive index afford had largely to be relied upon, and the figures of the oil recovery, yields of gas and of the various products, carbon formation, tar, &c., cannot claim any accuracy. Hydrocarbons boiling below or about 150 deg. C. were regarded as gasolines, it would appear. But the experiments were checked by experiments starting with pure hydrocarbons as raw material, and the yields of 16 or 13 per cent. of gasoline or aromatic hydrocarbons (*i.e.*, per cents. above the yields realisable by direct distillation of the material) may thus be accepted as decidedly satisfactory. Some of the experiments were conducted in apparatus of much larger dimensions.

The chief result is that with proper temperature, pressure and feed relations, either gasoline or aromatic hydrocarbons can be cracked at will from any oil as raw material; in a certain sense, the conclusions hold for the treatment of coal, lignite, bitumen, &c., though, of course, the materials are not equally valuable. The formation of gasoline is favoured by temperatures of 500 or 550 deg. C., at moderate pressures of 12 atmospheres or more. Aromatic compounds are formed chiefly at temperatures ranging from 625 to 700 deg. C., at pressures of 8 atmospheres or a little more; the lower temperatures are favourable for toluene; increase of pressure up to the limit stated is advisable. The stability of these aromatic compounds decreases in the order benzene, toluene, xylene, cymene; all the three xylenes are formed.

The results were considered sufficiently encouraging to arrange for a public demonstration of the process in the Columbia University Laboratory. The demonstration took place on March 8, 1915, and on the following day the Aetna Explosives Company, of New York, offered to co-operate with the Bureau of Mines in the development of the processes at an expenditure of not less than 200,000 dols. An agreement was drawn up by the two parties and by the Secretary of the Interior, acting at Trustee for the people of the United States, to remain in force until June 30, 1916, at the latest. The experiments were to be made in the works of the Explosives Company at Pittsburgh, under the direction of Mr. Rittman, the company to pay also the salaries of Mr. Rittman and his assistants, though they might not give their full time to the special work; all patentable improvements, &c., suggested by either side were to be assigned to the Trustee, and no publication of apparatus and methods was to be made by either party without the consent of the other during the term of the agreement. Patents were, as a matter of fact, applied for, and the Secretary of the Interior was to issue, in due course, licences, without royalties, reserving to himself the assignment of any further patentable improvements arising out of the working of these processes. As legally no licence can be granted in the United States before the actual grant of the patent, a provisional form of licence was drawn up. This mode of co-operation of a Government department with a commercial firm constitutes in itself an interesting novelty.

The *Bulletin* describes the "Large-scale Development of the Benzene-toluene and Gasoline Processes" in detail, illustrating the plant. As long as the experiments were confined to single tubes, 4½ in. diameter up to 10 ft. long, and rates of feed of 10 gallons per hour, things went on smoothly. But when 10-tube batteries, heated with natural gas, were set up in brick furnaces, matters looked for a time gloomy, especially with the crude Oklahoma oil, mostly used. The lower part of a tube might mark 750 deg. C., the upper 500 deg. C.; the base-metal pyrometers would be ruined in a few days, and eye estimates and optical pyrometers were adopted. The tubes were made of ⅛ in. plates, double extra-heavy lap-welded, supplied in stock lengths of about 23 ft.; they did not actually burst, but defects developed in the seams, and they bulged after ten days' use and wore down locally to the thinness of a knife edge, whilst single tubes lasted five months. Rolled or cast steel tubes, 1 in. thick, would appear preferable. The fact that stirrers had to be used for scraping out the carbon had much to do with the trouble. Each tube was provided with an axial rod, passing below through a stuffing-box to a gearing which was driven by a chain from a reversible electric motor. Placed horizontally, the rod looked like a staff to which a great number of chains (of short length) were attached; in the tube the chains were thrown by the rotation against the tube walls, wiping off the soot or coke deposited. But when the ten rods of a battery were set in simultaneous rotation, the whole tube system began to vibrate unpleasantly, so that the expedient was adopted to rotate each rod for two minutes and then pass on to the next rod. Originally a rod had to be removed every day, finally after ten days.

* "Manufacture of Gasoline and Benzene-Toluene from Petroleum and other Hydrocarbons." By W. F. Rittman, C. B. Dutton and E. W. Dean; with bibliography compiled by M. S. Howard. Bureau of Mines *Bulletin* 114 (Petroleum Technology 29). Washington, 1916. 267 pages.

† ENGINEERING, August 6, 1915, page 144 (Bjerregaard experiments); November 5, 1915, page 475 (McAfee process); January 14, 1916, page 38; and April 7, 1916, page 329 (gasoline from natural gas).

Some of these rod and carbon removal troubles decreased when the temperature regulation in the battery had been improved. One does not quite see why that regulation, which was never perfect, is so very difficult in a battery when relatively easy in a single tube. The rod itself transforms the tube furnace into an annular chamber, which is an advantage for the temperature equalisation, and if it were not for the feed and scraping troubles, one might like to try concentric tubes as furnaces. The feed and condensation difficulties were great, partly because it was desired to work every tube independently of the others. Each tube had its pump and needle valve for the feed at rates up to 33 gallons per hour and a separate condenser. The pumps did not always give satisfaction, and the condensers were suitable for runs of 5 hours, but not of days. One terrible accident occurred. Before tapping the condenser for withdrawing liquid, the men were to release the condenser pressure, which might be 250 lb. per square inch; this was once forgotten, and the gases, rushing out, caught fire and burned five men to death; their clothes were spattered with oil.

In spite of all the difficulties the Aetna Company was so convinced of the success of the Rittman process, especially for making benzene and toluene for explosives, that they terminated the agreement with the Secretary of the Interior in September, 1915, when their works for making explosives from benzene and toluene were ready. That the aromatic hydrocarbons obtained were suitable for this purpose and for the manufacture of dyes had been sufficiently demonstrated. As regards gasoline it was established that a barrel (of 42 gallons) of oil would yield from 33 to 37 gallons of gasoline in three or four runs; the conversion could be perfected by running the residuum again through the furnace. The toluene formation was, with Oklahoma oil, best at about 650 deg. C.; the benzene production bore and required higher temperatures, being satisfactory up to 800 deg. C. Coal tars, it should be noted, contain about three parts of benzene for one of toluene, in addition to naphthalene, anthracenes, &c. The tube dimensions had been raised in some experiments to 14 ft. by 8 in. diameter; with the tube length the capacity increases, but the optimum length was found to have been exceeded, and 10 ft. with 8 in. diameter are recommended. It is suggested that the diameter might be raised to 18 in. Considering that, in the batteries of 10 tubes, two symmetrically-placed tubes would sometimes behave very differently, that suggestion seems to lack the necessary experimental basis.

Information about the costs is not offered, and further experimenting seems advisable before proceeding to the actual laying down of plants. A fair share of credit for the success realised is, of course, due to the engineers, and special acknowledgment is made under this head to Messrs. C. Stutz and S. McMillan, of Messrs. Mackintosh, Hemphill and Co., Pittsburgh. We think that the engineer will have to bear the main share in solving the motor-fuel problem for other reasons as well. The petroleum resources of the world are limited; all cracking processes are wasteful; there are justified prejudices against cracked oil products; and other oil mixtures and fuels can be utilised in internal combustion motors. We will consider these points for a moment.

The natural oil stores of the world threaten far more rapid exhaustion than the coal stores; for this reason Mr. Van. H. Manning, Director of the Bureau, in a preface to the *Bulletin* 114, decidedly deprecates the use of oil fuel for steam-raising. Cracking will no doubt be rendered less wasteful, the formation of hard crusts of coke in particular will more and more be avoided, and the apparatus will be simplified. That is one of the reasons why we feel inclined to submit that the problem is not yet mature for the plant-designing engineer. Cracked illuminating oil is, or was, objected to because its colour darkens and its light-giving power is inferior, both probably on account of the presence of unsaturated hydrocarbons. The odour of cracked oil —whatever its cause—is also objectionable in cracked gasoline, which is further accused of giving a great deal of soot. According to W. A. Hall* this trouble should really be ascribed to the use of mixtures which are too rich, and a properly cracked gasoline should burn more slowly than a "straight" distillate and thus impart power to the piston during the entire stroke; this would particularly be noticeable when automobiles are climbing up hill, and be an advantage. This objection probably falls, therefore, though the production of olefins is unprofitable. Finally, we come to the use of blended oils and of oil substitutes. For boat propulsion under fairly uniform conditions large percentages of paraffin may be added to the petrol; there will be more soot, however, and more frequent cleaning of the engines will become necessary. With motor-cars which have constantly to speed up hill, to slow down, and to stop, the use of paraffin is much more troublesome. Alcohol-motors have not made progress. But that brings us to our final point. Is it not the duty of the engineer to adapt his engine to the fuel? since he cannot rely upon having the one fuel for which he has perfected his engine always at his disposal in sufficient quantity. More could certainly be achieved in this respect than has been done. The Diesel engine is not the universal primary motor, but it has proved a triumph in its line.

* Presidential address to the Institution of Petroleum Technologists, February, 1915.

GERMAN INDUSTRIAL COMBINATIONS.

The longer the war lasts, the nearer must be its termination, and all the belligerent Powers, perhaps with the exception of one or two Balkan States, are getting ready to take up the industrial and commercial struggle which will follow immediately upon the conclusion of peace. In Germany, which has suffered commercially more than any of the other Powers, new developments and movements have already been going on for some time with a view to meeting the after-war problems in the most efficient manner. The leading features seem to be a tendency to centralisation on a large scale and, in one or two instances, at least, on a basis comparatively, if not altogether, new to German industry.

Although no country has treated her opponents more contemptuously or libelled them more grossly than has Germany, she, strangely enough, seems to feel little apprehension of a long duration of hostile feelings and sentiments. A German paper of some standing states confidently that quality and price ere long will exercise their usual influence. As to quality, the war has not only not reduced the work of Germany's experimental plants and laboratories, but, on the contrary, it has enhanced their activity. They are endeavouring to arrive at better processes of manufacture in order to benefit the quality and, more especially, advantageously to influence the price of goods. One of the principal aims of the industrial combines is to make the manufacturing methods as rational as possible. The superiority of large concerns has proved so striking, that even whilst the war is raging efforts are being directed towards increasing the capacity of numerous works by extensions, and still more by combining with concerns already in full swing, so as to make the works independent in the matter of raw materials and intermediate manufactures and to render them capable of a price-reducing mass production. This movement has been going on for the last decade or two; it has been accelerated during the war, and is likely to be so to a much greater degree with a view to the solution of the problems which await the German industry after the war. In many industrial branches a strong demand is then anticipated with regard to many products which either could not be manufactured at all during the war or only on a limited scale, others apprehend serious difficulties in the matter of raw materials, and others, again, feel some concern about the return of the disbanded soldiers to peace employment. In all these cases it seems as if combines were looked upon as a great and potent aid, both financially and by placing the undertakings on a broader basis.

One of the most important combines is that in the chemical industry consummated some little time ago, and also in the metallurgical and mining industries large combines have been and are going on. The firm of Fried. Krupp, besides starting large new works in Munich, is endeavouring to establish its independence in the matter of raw materials by acquiring iron, copper, coal mines, &c. Thus the Wolf iron ore deposits, in Herdorf, which are some of the richest mines in the Siegerland district, have recently passed into the hands of Krupp, and this vast undertaking has also secured the Hermannssegen ore deposits, at Niederfischback, also in Siegerland, and the Giesen deposits for a sum exceeding 4,500,000 marks. Krupp is also said to be desirous of securing the manganese deposits, Glückauf Hessen, adjoining the last-mentioned mines, as well as the iron mines Jacobkrone and the manganese ore deposits of Fliek. The Krupp firm has also made other purchases of mines in Siegerland during the present year, and has bought the Becker ammunition works in Desson for 3,000,000 marks. There are also other amalgamations within the mining and iron industry, either already completed or still pending. Thus the Georg von Giesche Heirs has secured the majority of shares in the Westfalen concern; this is probably the forerunner of further industrial developments, inasmuch as the purchasing undertaking cannot profitably carry coal from Westphalia to their zinc works in Silesia, where they already own coal mines with a capacity of 4,000,000 tons per annum. The Bochum Union and the Friedrichshütte in Herdorf are both anxious to secure the Einigkeit iron mines at Pfannenberg. These negotiations are carried on in the interests of the "mixed" extension of a similar character as that which has prompted the deals undertaken by the Phœnix, the Thyssen and the Gelsenkirchen concerns and as the contemplated amalgamation of the Sieghütter iron works and the Eickener rolling mills. Independent coal and lignite concerns are much coveted as objects of amalgamation, and now more than ever, as the large "pure" works, or works proper, in the interest of an independent supply of raw materials, seem very anxious to acquire possessions which can answer this purpose.

Other industries are also undertaking large extensions or are amalgamating in order to be better able to meet the expected increased demand after the war. This, for instance, applies to several large firms in the motor-car industry. The Rhenish Automobile Company has been amalgamated with the Benz works; the Adler works at Frankfort have bought the remaining site of Allgemeine Elektricitats Gesellschaft Lahmeyer works for some 2,000,000 marks for the purpose of enlarging and perfecting their manufacture. The Opel concern, Russelsheim, has bought an extensive site at Schöneberg, Berlin, in order to erect large works there; the Wanderer Company has increased its capital in order to buy a site for additional works. The Daimler Company some time ago acquired land in order to extend their works at Marienfelde, near Berlin, at Untertür Kheim, near Stuttgart, and at Sindelfingen. The new works are expected to be completed next year.

A similar movement to the one within the iron industry is also on foot within the chemical industry, here likewise prompted by the desire to become as independent as possible in the matter of raw materials and to escape from the control of the Rhenish-Westphalian coal syndicate. Thus the chemical concern von Heyden, at Radebene, near Dresden, has purchased some lignite deposits in the Zittau district, and the Ludwigshafen-Leverkusen-Trepton concern has also decided to become possessed of lignite deposits of its own; the Baden Aniline and Soda Works are endeavouring to secure lignite deposits in the Merseburg district for their own works, and the capacity of several areas is being tested by fairly extensive borings. The Friedrich Boyer dye-works, Leverkusen, want lignite deposits in the Cologne district, &c.

All this goes to show that Germany does not mean to be found wanting in the coming commercial struggle.

MONOCHROMATIC PHOTOGRAPHY OF JUPITER AND SATURN.

Some time ago attention was called in these columns to the interesting results obtained by Professor Wood, of Baltimore, in his photographs of the moon through light filters, or screens, which transmitted limited regions of the spectrum. Under the conditions imposed by the quality of the light,

the moon assumed a sensibly different appearance, dark areas that were not visible to yellow rays or a normal eye being revealed by ultra-violet light. Such changes of illumination would result from the presence of sulphur or sulphur-bearing rocks, and by this method of investigation the existence of such materials in the composition of the moon's surface is rendered highly probable.

The next step in advance is evidently to photograph the planets, and the application of the method to Jupiter and Saturn seems easy and obvious. The smaller size of the image, however, and the finer detail of the surface markings demand nicer manipulation and adjustment of apparatus than in the case of the moon, and the success that has rewarded Professor Wood is the result of much perseverance and elaborate experiment. A 16-in. nickelled glass mirror of 26 ft. focal length, mounted equatorially, could not be guided with the necessary accuracy, and the substitution of a reflecting telescope of 56 ft. focal length in connection with a coelostat, though showing some improvement, would not give pictures having the required detail. As any improvement in the driving could hardly be expected, Professor Wood decided to dispense with the nickel-coated mirror, a device that reflected the ultra-violet spectrum much better than the silver deposit, and to adopt silver mirrors in connection with specially constructed screens that permitted the passage only of restricted regions of the spectrum. A cell filled with dense bromine vapour would transmit the entire ultra-violet region below λ 3,500, while silver reflects the region λ 3,300–3,500 sufficiently well to make photography possible with silver glass mirrors. In this way shorter exposures would be possible and the effects of inadequate driving diminished. With bromine vapour used in connection with a dilute solution of potassium chromate, the light transmitted was comparable with that given by using a deposit of silver on a thin quartz plate, the plan Professor Wood had adopted in previous experiments, but the intensity was increased tenfold. Such an arrangement of screens permitted the conduct of the experiment to be transferred to Mount Wilson, where the 60-in. reflecter would be available, giving more light and great control over the driving. At this observatory the experiments were successfully carried out.

In all, four screens were used, an infra-red transmitting wave lengths above λ 7,000, a yellow screen giving everything above λ 5,000, a violet region including λ 4,000–4,500, and the ultra-violet region extending from λ 3,500–2,900. Jupiter and Saturn were both photographed with each of the four screens, but the most striking variations were shown by Saturn. With the infra-red screen, all surface markings were practically suppressed. With the yellow screen, the narrow belts were distinctly seen as on the ordinary visual image. The violet-ray filter, however, disclosed a very dark belt surrounding the planet's equator, and occupying the portion of the planet which is brightest in yellow light, while a hitherto unsuspected dark polar cap of considerable size was clearly manifested. "So different were the two pictures," says Professor Wood, "that were it not for the ring it would be difficult to believe that they represented the same object." The equatorial belt and polar cap were visible with the ultra-violet light, but not so prominent.

Photographs of Jupiter made with the same four filters showed a different distribution of light and shade from that with which we are familiar, but less pronounced than in the case of Saturn. The dark belts were scarcely visible on the infra-red plates, while the photographs made with the violet light show these in the greatest contrast. The gradual darkening of the limb, so pronounced a feature in ordinary light, is scarcely noticeable on the infra-red plates. Also "the two dark belts above the bright equatorial belt have a number of still darker spots on them, which are most distinct in the yellow picture, less so in the violet, and almost invisible in the ultra-violet. Above this dark belt a double bright belt appears in the violet and ultra-violet pictures which cannot be seen in the infra-red and yellow pictures. The upper dark polar cap shades off gradually in the yellow and infra-red views, but is sharply terminated in the violet and ultra-violet, its lower edge marking the upper boundary of the double bright belt." Since the surface markings of Jupiter differ greatly at successive oppositions, it is important to bear in mind that the photographs were taken in October, 1915, and the deviations noticed refer to the general appearance of the planet at that time.

The combination of the pictures obtained with different coloured light into a composite picture by a kind of three-coloured printing should give interesting results, as the resultant image represents the planets as they would appear to an eye having a wide range of sensitiveness. As is well known, when three negatives are made of an object through red, green and blue filters, and the positives made from them on bichromatized gelatine are stained with appropriate dyes, it is possible to obtain a fairly faithful reproduction of the object in its natural colours. Professor Wood has applied such a scheme to the pictures obtained by yellow, violet and ultra-violet light, the result being a picture of the object as it would appear to an eye sensitive to ultra-violet light. Saturn's photographs, grouped by this method, show the ball yellowish in colour with a broad orange-red band surrounding the equator, and a dark red polar cap. "The narrow belts which can be seen visually and which appear on the negative made with yellow light, come out blue in the picture, the lower one being in coincidence with the upper edge of the dark belt. The upper edge looks yellow in the finished picture, and the superposed narrow blue belt appears purple in consequence." Of the rings, the inner appears white and the outer bluish-green. Jupiter's photographs, being treated in the same way, show less deviations from the ordinary view. The photographs leave the impression that we are dealing with great belts of selectively absorbing, coloured vapours or gases. An eye sensitive to a wider range of spectrum would see and describe a much more highly coloured picture than that shown in the telescope.

It is natural that we should attempt to explain the altered appearance by physical causes. Professor Wood, dealing more particularly with Saturn, suggests two hypotheses. First, the existence of a fine mist or dust forming an extension of the crape ring down to the ball of the planet. This suggestion receives some support from the fact that the sky between the ball and the ring is denser than the region outside, indicating the presence of a material capable of reflecting light of short wave-length. Notwithstanding the plausibility, Professor Wood is not enamoured of this hypothesis, for precise measurements made by Mr. Ellerman showed that the belt extended higher up on the ball of the planet than the line of intersection of the plane of the rings. Moreover, it would be satisfactory to explain the belt and the dark polar cap as parts of the same phenomenon, or arising from a common cause.

The second hypothesis, designed with this end, assumes the presence in the planets' atmosphere of some substance as fine mist or vapour, capable of absorbing violet and ultra-violet light. The difficulty in this hypothesis is that we should expect the effect to be intensified in the ultra-violet light, as indeed is shown in actual experiment with sulphur vapour or chlorine gas, whereas the maximum effect in the planet photographs is shown in the violet light. This decrease in contrast when employing the shortest wave-lengths is puzzling, as is the similar decrease of contrast between the inner and the outer ring. This latter peculiarity might be explained by supposing that the outer ring contains so much finely divided matter that it shines in part by diffusion. While congratulating Professor Wood on his results—results that open new and far-reaching lines of inquiry—it is evident that much work will have to be done with the spectroscope, and much ingenuity displayed, before the solution of the problem can be attained.

NOTES.

Trajectories of Projectiles Discharged at an Elevation of 45 Deg.

Many months have elapsed since the newspapers mentioned a bombardment of Dunkerque by a German gun at a range of more than 20 miles. Very little, if anything, has been heard of that gun since. The news, however, induced M. de Sparre to address several communications, in December, 1915, and in January and April last, to the Paris Academy on the trajectories of projectiles discharged with high velocities at elevations of about 45 deg. He points out that projectiles would under these conditions rapidly enter layers of an atmosphere of very much reduced density, and he calculates the trajectories on the basis of the formulæ of Charbonnier and of Siacci, which he extends for his purpose. Assuming that the gun has a calibre of 381 mm. and that the projectile weighs 720 kg., and accepting the figures for normal German ordnance as given by Cranz and others, including the ballistic index 0.865, he calculates that the high elevation of 45 deg. increases the range by from 35 to 40 per cent. and by about 10 km. in this instance. The velocity of the projectile would pass through a minimum after the shell had reached its summit, and then increase to a maximum, finally to decrease again. In his last communication he considers that the index 0.865 is probably too high, and he recalculates his data for a ballistic index of 0.75. The velocities he arrives at for different parts of the curved trajectory are: 940, 592, 443, 386, 394, 437, 433 m. per second, these figures corresponding to curvatures (in round figures) of + 45 deg., 36½ deg., 20⅔ deg., 0 deg., — 25 deg., — 45½ deg., — 58 deg. He also makes calculations for another gun of 406.4 mm. discharging shells of 920 kg. weight; in this case he deduces a maximum range of 40 km. Finally he inquires into the influences of temperature and barometric pressure. Those influences would be exceedingly strong, both a fall of temperature and a rise of the barometer tending to shorten the maximum range very considerably. In comparison tables he gives the results of calculations made for an atmosphere of constant density.

Silicates, Water-Glass and Artificial Stones.

The study of the formation and stability of minerals, and of the silicates in particular, is theoretically very interesting, and has an important practical bearing. The little that has been done in this field has mostly been by the fusion method; but the hydrothermal method is at least equally promising. For many rocks and minerals, once regarded as obviously igneous, are now considered as products of aqueous decomposition, partly at high temperatures and pressures, and that applies also to metallic veins. Three years ago George H. Morey and Paul Niggli, of the Geophysical Laboratory of the Carnegie Institution, Washington, prepared some new silicates by fusing silica and alkali salts together and by heating the resulting glass, or the raw materials, with water in gold crucibles, enclosed in steel bombs, up to 500 deg. C. These researches were described in the Journal of the American Chemical Society of 1913 and 1914. Similar experiments have since been conducted, with more modest means, by W. Pukall, of the Keramic School at Bunzlau (*Berichte Deutsch. Chemische Gesell.*, 1916, pages 397-437). Pukall first prepared series of silicates, both of potassium and sodium, by fusing one molecule of potash or soda (as carbonate or bicarbonate) together with from one to six molecules of silica at temperatures up to 1270 deg. C., and then studied the action of cold water and of superheated steam (in sealed glass tubes) on the products. That the monosilicate of potassium is deliquescent was already known to Helmont, the alchemist of Brussels, 300 years ago. The tetrasilicate of potassium, which readily dissolves in water and was hence called water-glass, was discovered by Fuchs in 1818. It has formed the starting-point of many researches on metallic silicates, undertaken for various purposes, also in the hope of finding a leadless glass for earthenware. That is one of the objects also of Pukall's recent studies, in which he has so far had little success, however. None of the higher silicates resisted the long-continued action of much cold water; they were all decomposed, finally leaving an insoluble residue of silica almost free from alkali. The action of small amounts of superheated steam revealed the existence of several distinct potassium compounds, but only of one sodium silicate, $Na_2Si_2O_5$, 0.5 H_2O, which crystallises in hexagonal plates, and it would appear that fusion and hydrothermal action yield two different series of silicates, both built up by adding new molecules, the members

differing in stability. The hydrothermal series always contains the group $(OH)_2$ and an even number of silicon atoms. The zeolites and feldspars, so far regarded as double silicates, would appear to be compounds of this second type with aluminates or ferrites, in which the silicates act as cements. When sand, clay (burnt or not), and granite chips are mixed with about 10 per cent. of a silicate high in silica, compressed and then treated with superheated steam, hard artificial stones are obtained. But only the stones containing potassium silicates are stable in water; when the stones are made with sodium silicates, the leaching action of water does not stop after a while, as it does with the potassium stones—which remain hard, while this slight leaching proceeds—but continues until they decay. This is geologically and practically interesting. Another point may be mentioned. The loss of potash from the acid potassium silicates of the second, hydrothermal series (not the artificial stones just referred to) is very slow, and such silicates may prove more suitable and less expensive as potassium fertilisers than the more soluble potassium salts now used. The acid silicate, which chiefly seems to answer as a fertiliser, is the same which promises well as glaze for earthenware; its formula is $K_2H_2Si_4O_{10}$, and it is readily fusible.

German Industries.—The Hohenlohe Works, like a number of other German industrial concerns, have done considerably better during the year 1915–16 than during the previous year, declaring a dividend of 6 per cent. for last year, against *nil* for the preceding year, in addition to which the writings-off absorb 6,500,000 marks against 5,900,000 marks in 1914–15. The A. Riebeck mining concern, Halle, pays 12 per cent. for last year, against 10 per cent. for the previous year, although the writings-off are about 500,000 marks higher, and the sums applied to war aid for officials, hands, &c., absorb 1,000,000 marks more. The Benz Motor Company, Mannheim, has had a remarkably good year, the gross profits amounting to 30,970,000 marks, against 19,800,000 marks and 14,940,000 marks respectively for the two preceding years. The net profits were 13,020,000 marks, against 8,900,000 marks for the previous year, and the dividend for last year was 20 per cent., against 12 per cent. for the preceding year.

Production of Zinc in Australia.—The project for the production of zinc on a commercial scale by the electrolytic process has been advanced a stage further by the registration of a company named the Electrolytic Zinc Company of Australasia Proprietary, Limited. The company is primarily formed for the production of zinc electrolytically in Australia. The Company will be one of the members of the Zinc Producers' Association Proprietary, Limited, a company which was recently registered, and to which all the zinc-producing companies of Australia are parties. It is to be a cardinal feature of the company that it is to remain under British control. The company is the outcome of the investigation begun by the Amalgamated Zinc (De Bavay's) Company some time ago into the operation of the electrolytic process of extracting zinc from ores, as applied in America. Results were considered sufficiently encouraging some months ago to justify the company's making a tentative arrangement with the Tasmanian Government Hydro-Electric Department for a large "block" of power from the Great Lake scheme. As a preliminary, it was decided to erect a working unit of the plant in Tasmania, so that the investigation would be thorough before a scheme to erect the large works necessary to deal with any substantial portion of the Broken Hill output of zinc ore was launched.

Petroleum in Oklahoma.—The Gravenhagen Syndicate, which owns certain petroleum territories in the new American State of Oklahoma, has been liquidated, and has been taken over by the Roxana Company, in which, in conjunction with the Royal Dutch Company, the Shell Transport and Trading Company, Limited, holds a large interest. The production of the Roxana Petroleum Company amounted last year to 1,784,000 barrels, as compared with 561,000 barrels in 1914. The large increase in the production was due to the acquisition of 680 acres of oil-producing territory situated in the Healdton district, and producing 9,700 barrels per day; the territory was purchased in order that the undertaking might be independent of pipe-line companies. The company has erected storage with a capacity of 550,000 barrels, and the wells may be worked to a great extent, so that the company now obtains the full benefit of increased oil prices. In addition to this oil-field the Roxana Company acquired in May, 1915, 320 acres of oil-producing territory in the Cushing district. At that period the fields produced from 6,000 to 7,000 barrels per day; and although the production decreased at first, the output has for some time amounted to between 8,000 and 9,000 barrels per day, in consequence of the drilling of wells in deeper strata. As the oil contains a high percentage of refinable products, and better results can be obtained than by marketing it as crude, a distilling plant at Cushing with a working capacity of 3,000 barrels per day is in course of erection. The Cushing and Healdton territories were acquired at a period when the price of crude oil was low.

LITERATURE.

The Tropics: Their Resources, People and Future. A Description of the Tropical Lands of Africa, Asia, Central and South America, Australasia and the Pacific. By C. R. Enock, C.E., F.R.G.S. London: Grant Richards, Limited. [Price 16s. net.]

Mr. Enock, we believe, is a mining engineer of reputation, but is equally well known in the world of letters as a writer on the Latin Republics of South America. He has travelled extensively in the less accessible parts of the world and made good use of his opportunities. Gifted with acute observation and keen intelligence, and possessed of a style at once facile and graphic, his books have proved informing and attractive. Sympathetically inclined towards aboriginal races, but also conscious of their shortcomings, and profoundly interested in all that makes for the historic and industrial progress of nationalities, he has been at great pains to gather accurate information concerning the material resources of the countries described, their natural wealth, their economic outlook, and their political future. Moreover, his study of the physical features, wrought on the magnificent scale that distinguishes South America, has convinced him of the important influence that topographic and geographic environment can exercise on peoples, and induced him to prosecute researches on "constructive human geography," of which the present work is in some measure the outcome.

This new division of geographical science apparently owes its origin and its advocacy to a benevolent regard for the welfare of the native races, and we should scarcely have expected to find such stout championship in one whose description of tropical countries has done much to encourage European capitalists to invest their money in exploiting the resources of backward countries, and in persuading European immigrants to settle and develop improvements. For if we correctly understand the author, this new science of "constructive human geography" aims at building up a society on a basis of contentment with the environment in which it finds itself placed. The object of this science appears to be not the broadening of common interests, but their restricted localisation, not the effort to introduce varied enterprise and increased endeavour where torpor and incapacity have held sway, but to confine the business and profit of a locality as far as it is physically possible to the production of those things that are consumed in that locality. A process of self-supply and self-support is the goal at which the author would arrive, and complacently surveys. Such a theory is economically unsound, and we can neither approve of his arguments nor accept his conclusions without decided limitations. It is not difficult to point to evils and crimes that have disgraced the conduct of the white man in his intercourse with primitive peoples. Rapacity and greed have no doubt worked much mischief, and the author, writing with a conscience quickened by the memory of the Putumayo atrocities and the cruelties practised in the Congo rubber district, may be excused for taking a disproportionate view of such crimes. But he can never cure latent evils by destroying a positive good. He allows that overseas trade has conferred enormous benefits upon the world and has been one of the most powerful agents in the spread of civilisation, but he urges that the advantage accruing to the foreign trader, in selling his manufactured goods to, and acquiring raw material from, native producers, has been dearly purchased by the loss of native independence and native industries. It is admitted that the coloured people of the Equatorial Belt have not acquired the capacity for producing textile materials, machinery, and other things necessary to the citizen of temperate zones, but it is urged that the proper course would have been to have encouraged their mechanical training and enlarged their output. So far from encouraging native effort, it is urged that what facility and adroitness these primitive people have displayed has been suppressed in the interest of the trade of the white nations who hold them in economic thrall. The cry has ever been for more labour and cheaper labour, to work gold mines, to cultivate rubber plantations, to produce cotton and other crops that are valued in remote countries.

In these charges there is some truth, but the author seems to confound many issues and to take an exaggerated view of the value of native industries. History and experience alike teach that improvement beyond a very limited point is not possible without the introduction of a foreign element. Some stimulus is needed to prevent decay and retrogression. Mr. Enock looks back with regret on the art treasures that were evolved by the ancient races of Central and South America, who faded away before the Western Conquerors began their reign of rapine and cruelty. The selfishness of trade, the degrading influence of commercialism, the rivalry of competing nations were not concerned in their disappearance, but on the ruins of these defunct tribes will arise other and more virile peoples, who in their turn will carry forward the torch of civilisation, and by a gradual evolution that ensures only the survival of the fittest, raise the scale of humanity and prepare the way for further and continual progress. The evil, the degraded, and the incompetent will necessarily disappear from the face of the earth, but those who enter into the new order, improved by the discipline and strengthened by the ordeal, will give birth to new nations to carry on the world's work. This process of material and intellectual progress by which the conditions of life are softened and aspiration promoted will be repeated again and again, and we have no difficulty in recognising trade enterprise as a part of the machinery of progressive evolution. On the other hand, abuses there will be, "the means to do ill deeds will make deeds ill done," but there is no need to exaggerate these. We can, however, welcome any genuine attempt that by insisting on their mischievous character aims at reducing their evils to a minimum.

Mr. Enock, in his enthusiasm for promoting an "Economic Equilibrium," raises a question to which he does not give an answer, and to which perhaps no satisfactory answer is possible. Why have the tropical localities, generously endowed as they are with natural wealth, favoured with easy conditions of life, and enjoying a genial climate, failed to occupy and maintain a foremost place in the world's advancement. We could have wished that this interesting survey, in which is passed in review the physical features and varied productiveness of the tropical belt as a whole, presenting a tolerably complete picture of earth's fairest land, threw more light on this baffling problem. Enduring civilisation and the furtherance of national progress seem possible only under those strenuous conditions of life that compel the exhibition of sustained energy and make work a stern necessity. Will this ever be the rule of progress? Will not exhaustion follow on exertion and enervation be the consequence of a closer alliance with those lotus-eating lands that seduce to repose? Is nothing to be feared from a migration to those tempting congenial climates, access to which is rendered so fatally easy by the facilities for modern travel. The author hints at a closer intimacy with, and a juster appreciation of, the ambitions and capabilities of the varied communities of the tropics knitting the whole world together by ties of friendliness and mutual goodwill. Whether such a result would be for the benefit of the whole may be questioned. Progress may not be compatible with uniformity. In the physical world we know the necessity of preserving the ready transformation of energy. When a number of bodies are at the same temperature, we get no work, and the thoughts and actions of the human race may be governed by an analogous law.

The descriptive portions of Mr. Enock's book naturally vary in value, and it is to be regretted that he was not more careful to distinguish between the results of personal observation and the deductions drawn from the works of other travellers. He must have consulted many authorities, and consequently sees men and cities through the medium of a very varied perspective. Starting from the West Coast of Africa and traversing that vast area that separates the region where the Portuguese, influenced by the exploring genius of Prince Henry, first came in contact with the black races in their native home from the far-off shores of the Red Sea, that limits the traces of the oldest continuous civilisation, the number of problems encountered even on

this one Continent, is too large to be treated exhaustively. The plan of colonisation as pursued by various advanced nationalities, their treatment of the native, his industries and his traditions, the varying responsive effort made by the different tribes to the call of European culture, the opportunities of the future and the mistakes of the past all conjure up a crowded picture of varied activity and unequal achievement, whose unravelment needs the skilful hand of a master. South of the equator, where the geographical configuration by facilitating exploration invited earlier settlement, the country is not less rich in problems for the student of evolution of ethics, of sociology and of commerce. The author devotes about half of his book to the study of Africa and is seen at his best in the descriptions of the French colonies and of Rhodesia.

Leaving the African continent, it is necessary to cross the vast area of the Indian Ocean, broken only by the southern portion of the comparatively small peninsula of India, the home of old philosophies and the heir of many civilisations, the object of so much study that it is difficult to add anything new. The narrow barrier of the Malay Peninsula, with the contiguous lands of Sumatra and Java that lead to the Continent of Australia, offers a problem in continent building and subsequent disintegration into a clustered archipelago that is of hardly less interest than are the fortunes of the peoples who inhabit these scattered islands and may be the descendants of our Aurignacean and Mousterian ancestry, who in geologic times found a continuous land route that favoured migration to Southern climes. Only the most northern, and that not the most interesting or progressive portion, of Australia lies within the tropics, and the author has not been tempted by the prosperity of the Southern areas to extend his survey beyond the tropic of Capricorn. The scattered islands of the Pacific, to most of us little more than names, but suggestive of scenes of great natural beauty in which man's passions have found a field for their worst development, provide resting places as we cross the Pacific and relieve the monotony of the great ocean.

Arriving at the American coast from the Sandwich Isles, which lie just within the tropics, we can pursue our way either northward among the Republics of Central America to Mexico or southward to the lands where the mild Inca once held sway, but in either direction Mr. Enock is on familiar ground and proves an efficient guide. The Panama Canal forms easy access to another archipelago, that of the West Indies, whence we may reach the eastern coast of South America without quitting the tropics, and follow the author in his enthusiastic description of the gigantic possibilities that lie concealed in the vast area of the Republic of Brazil.

It is a long journey that the author invites us to take, and sometimes we find his facts so numerous as to be a little bewildering and tedious, but his suggestiveness and enthusiasm never weary. We readily admit, too, that his plan of embracing the whole panorama of tropical activity in one comprehensive picture is happily conceived and adequately accomplished.

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PLATINUM.

PLATINUM, which was discovered as recently as 1784, has many rare physical properties surpassing those of all other commercial metals. Its specific gravity is greater than that of any other known substance, with the exceptions of iridium and osmium, with which it is generally associated in the crude state, and to which it has the closest mineralogical affinity. The melting point is far higher than that of any of the metals in general use; the coefficient of expansion is an extremely low one. With few exceptions it resists the attacks of all acids; whilst it differs from all other metals used in the arts by being absolutely unaffected by the corrosive action of oxygen. In combination with its natural alloy iridium, it possesses a hardness that cannot readily be equalled. Its qualities are so exceptional and permanent that platinum has been selected as the most suitable material for the standards of weights and measures of most, if not all, countries of the world. When in a pure state platinum is relatively malleable and ductile and can be drawn into very thin wire or rolled into thin sheets or plates. The hardness is 4 to 5 on Mohr's scale and the metal can be scratched with a knife; the specific gravity is 21.5 when pure; the melting point 1,775 deg. C.; the electrical conductivity of platinum is only one-third that of gold. The coefficient of linear expansion per degree Centigrade is 0.0000089. The colour is light steel gray with a metallic lustre; there is no cleavage, the fracture is hackly. Platinum in the crude state generally occurs in small grains and nuggets, and frequently contains iron, rhodium, iridium and other elements in combination with it. The principal source of the world's platinum supply, which will be dealt with in detail below, is Russia, whence, during normal times, about 12,000 lb. are obtained annually. The crude Russian output is sent to France, Germany and this country to be refined, although attempts have been made by the Russian Government to refine the metal in Petrograd. The total world's output during 1914 was 263,453 oz. (troy).

Experimental studies of the quality and purity of platinum utensils, such as crucibles, wire gauze, dishes and so on, have been made by competent authorities, with the result that a delicate thermo-electric test has been evolved. This test allows a rapid estimate of the amount of included foreign matter, such as iridium, or iron, to be made without injuring the article tested, it is therefore being generally adopted by large purchasers of platinum ware. The loss in weight on heating and after acid washing has been determined for several grades of platinum crucibles, including pure platinum as well as of ware containing iridium, rhodium, and iron. From the results of this investigation it is now possible to foretell very closely what will be the loss in weight of a platinum crucible when heated, and thus a serious source of uncertainty in exact analytical chemistry is eliminated. Ordinary grades of platinum are found to lose from 0.7 to 2.7 milligrammes per hour per 100 sq. cms. of surface at 1,200 deg. C. Platinum is very resistant to the action of mineral acids, especially when cold, but in boiling concentrated sulphuric acid containing 90 per cent. of monohydrate the metal dissolves in the proportion of 14½ grains to 1 ton of acid; the greater the concentration of the sulphuric acid, the more platinum it will dissolve. Therefore, in the manufacture of sulphuric acid by the old chamber system, its concentration in platinum reservoirs involved a relatively large loss of platinum. The action of pure muriatic and pure nitric acid on platinum is six times greater than that of sulphuric acid.

An important application of platinum is as a catalyzer, in what is technically known as contact mass in the manufacture of fuming sulphuric acid. The platinum does not enter into the chemical reactions, but appears to act as an exciter in the formation of sulphur trioxide, which on combination with water yields sulphuric acid. There are several varieties of contact masses in use, one is on an asbestos base and another on a magnesium sulphate base. The mass is made by soaking the base in solutions containing platinum chloride and then heating it for some time. This treatment induces a more or less complete distribution of very fine particles of metallic platinum throughout the mass. The quantity of platinum used varies within rather wide limits; some contact masses contain as much as 7 to 8 per cent. by weight of metallic platinum, whilst others contain as little as 0.2 per cent. It is impossible to ascertain the quantity of platinum used in the sulphuric acid industry, but it is probable that the loss of platinum in well-regulated practice is very limited.

Platinum utensils are essential in chemical laboratories and many chemical industries. The metal is also used in electrical laboratories and for electrical apparatus; but its use in the electrical industry is diminishing year by year. In the manufacture of incandescent lamps a large quantity of platinum was formerly used, but more recently wires made of nickel-chromium alloys, metallic tungsten, or metallic molybdenum have displaced platinum. Some years ago the resistance wires of electric furnaces and heaters contained a considerable proportion of platinum, but metallic molybdenum has now to a considerable extent replaced the more expensive metal. Some years ago the metal was extensively used in dentistry, but the phenomenal increase of price during the last decade has rendered it necessary to find substitutes for dental requirements. It is now probable that metallic molybdenum plated with platinum is extensively used instead of pure platinum. A considerable quantity of platinum is used in the manufacture of jewellery; the art of platinum plating has been so greatly perfected that the amount used in this way is much less than formerly; platinum is still considered the best setting for precious stones. It has also been extensively used in the manufacture of surgical instruments and cauteries as well as in instruments for burning designs on wood.

During the reign of Nicholas I, Emperor of Russia, platinum was used for coinage in values of 3, 6 and 12 roubles; the relative weights of which were 0.3355 oz.; 0.6710 oz., and 1.342 oz. The total quantity of platinum coins struck in Russia was 1,373,690 three-rouble pieces, 14,840 six-rouble pieces, and 3,474 twelve-rouble pieces. The total weight amounted to 473,140 oz. The striking of money, however, was stopped, as with the increase in the output of the metal the price fell, and consequently false platinum money was coined. The false money had the full weight of platinum, but the coiners gained the difference between the face value of the coins and the value of the metal. Platinum in minute particles is occasionally found in placer sands which are being worked for gold, and the problem of saving the platinum presents considerable difficulties. It is light and flaky and very elusive, and, as it does not settle, will be carried away with the waste dump unless special precautions are taken to retain it. Mercury will not hold it, so that the only means of saving the platinum is by separation. In the ordinary course of working, the sand, with its mineral contents, passes through sluices with a flush of water, and it has been found that the bulk of the platinum flakes are in the lower half of the sluice sand current. Mechanical means are therefore contrived to draw the lower half of the current through the bottom of the sluice, and this half is then spread over a broad table, or set of tables, covered with burlap, which catches and holds the sands with the platinum particles. The contrivance to abstract the lower half of the sand current is placed near the end of the flow, where it escapes to the waste dump, so as to prevent any interference with the regular operation of the sluices, and also to obtain the major part of the platinum sands. The contrivance in the sluice bottom is called a "grizzly," and is a sort of grating, made as wide as the sluice itself, and about 5 ft. in length, though the length as well as the size of the apertures have to be determined by the quantity of water used. Instead of a perforated grating a sluice bottom gate may be used and the gate may be regulated by varying the opening. This arrangement has the advantage of not getting clogged by stones and

pebbles as the grating does. So long as the lower half of the current containing the bulk of the platinum flakes is separated, the details of the device used for this purpose can be varied to suit local conditions. The burlap is rinsed in vats, the platinum flakes settle to the bottom and are recovered by careful panning.

Within recent years platinum deposits, which sometimes occur where least expected, have been found in several countries. The following easily applied *field tests*, which give reliable results when carefully carried out, may be found useful. The small scales or flakes found in sand deposit, which are of a distinctly metallic mineral appearance, range in colour from silvery white to steel gray, the shade depending on the proportion of impurities present. Occasionally the platinum grains are coated with a dark film somewhat resembling magnetite, from which, however, they can be distinguished by careful washing; the specific gravity will enable the platinum grains to be recognised. When sodium is added platinum will amalgamate with quicksilver; with ordinary quicksilver the platinum flakes float on the surface and can be removed. Platinum and gold are occasionally found together, in an amalgam with sodium, and the former can then be separated by agitating the amalgam with water until all the sodium is removed in the form of sodium hydroxide, when the platinum will appear on the surface of the amalgam, provided, of course, that it is sufficiently liquid. Platinum cannot be run together as gold can, and the only acid affecting it is a mixture of two parts of hydrochloric acid and one of nitric acid. Platinum dissolved in this acid gives a solution of platinum chloride, which is yellow, but the addition of metallic tin changes the colour to deep red. From this acid solution potassium platinic chloride (K_2PtCl_6), a yellow crystalline precipitate is formed, when potassium chloride (KCl) is added; or ammonium platinic chloride ($(NH_4)_2PtCl_6$, also yellow, when ammonium chloride (NH_4Cl) is added. Both these precipitates are insoluble in alcohol, but are soluble in water, and may be reduced by heating, so that spongy platinum is left.

Probably no metal has experienced more fluctuations in price than platinum, with the possible exception of silver. During 1874 its price was 1*l.* 5*s.* to 1*l.* 9*s.* per ounce, about one-fifteenth of its present value. A quarter of a century later the price had more than doubled, ranging from 2*l.* 1*s.* 8*d.* to 4*l.* 3*s.* 4*d.* During 1907 the average value became 7*l.* 5*s.* 10*d.* per ounce, but the following year there was a setback due, no doubt, to diminished commercial demand. Early in 1910 the value was only 7*l.* per ounce and in 1911 the value reached what was then a record price, 8*l.* 12*s.* During 1913 there was a further increase of value, the price being 9*l.* 10*s.* for refined platinum. At the commencement of 1914 the value of refined platinum was about 9*l.* per ounce, and the hard metal sold at 10*l.*, but at the end of that year the price fell slightly and continued lower during the early portion of 1915. During the autumn of last year there were rapid changes: For October the price was 10*l.* 12*s.* to 11*l.* 10*s.*; November, 12*l.* 10*s.*; December, 14*l.* 10*s.*, and at the end of the year 20*l.* per ounce. In February of this year the value was 18*l.* 16*s.* to 20*l.* 16*s.* per ounce. The very limited area in which platinum is found and the almost continuous increase in the demand during the last generation, suggests that the price of the metal will not greatly decrease.

Russia has always been the source from which the bulk of the world's supply of platinum has been obtained. The main output comes from the Ural mountains. During 1910 175,720 oz. of crude platinum was secured, while in 1913 the quantity was 250,000 oz. and during 1914 about 241,200 oz. The actual output is probably much greater, as a considerable quantity is sold without being officially recorded. The metal is found in placer deposits in several districts, of which the most important are: Teherdin, Perm, North and South Ekaterinburg and North and South Verkhotur. The output from these sources has been steadily increasing for a number of years. The richer placer deposits have been derived from the prolonged weathering of a variety of olivine, which occurs in the Ural mountains in a somewhat narrow zone. They occur also along the mountain slopes in the river beds. The average yield now is under an ounce of crude platinum per ton of gravel, formerly it was more. The workers have now either to exploit poorer placers, or to develop richer ones in more remote situations, which are not only more difficult of access, but also give more trouble to work. Prospecting has been carried on from time to time, but additional deposits are not readily found. Some of the districts have been worked for nearly 80 years. The Northern Urals have not yet been thoroughly explored, but olivine districts are known to occur there. Dredgers and excavators are now employed for working the deposits. Placer deposits in Colombia have been extensively worked by the Spaniards since the sixteenth century; they contain both gold and platinum, in the proportion of 90 per cent. of the former and 10 per cent. of the latter. Formerly, only the gold was recovered, and the platinum was thrown away. The districts in which the bulk of the platinum is found are on the Pacific side of the Andes, in the valleys of the rivers Atrato, Angueda and San Juan. Both the platinum and gold found in the placers have been eroded from veins in the rocks of the mountains high up the watershed, where igneous rocks containing platinum occur and several mining districts are situated. The largest platinum nugget found weighed slightly over 1 lb. (troy), but generally nuggets do not weigh as much as an ounce, and they are rare. The deposits are worked by the natives, and as the rainfall is a heavy one the rivers are deep and the metal bearing sands have therefore to be obtained largely by diving. No mechanical dredging has been attempted, the present system is slow and laborious, and the yield small, although it is after the Russian, the largest in the world. With suitable mechanical appliances to get at the deeper sands, which lie immediately on the bed rock, a much larger output could probably be obtained. At present the upper foot or so of gravel is worked over an area of several acres every year; every storm brings down from the higher levels fresh supplies of sands and gravel, so that occasionally the same area may be worked over twice in one year. The gravels on the head of the river bars are worked mainly by women and children. During unusually dry seasons gravels in the stream beds are worked, whilst the deposits on bed rock are reached by diving, the men carrying baskets for bringing up the deposit. To a limited extent the older gravels on the hill sides are also worked. The output of crude platinum in Colombia was 15,000 oz. during 1913, and 17,500 oz. during 1914. The figures for 1915 are not yet available.

The war has seriously affected the imports of platinum into the United States. For the last complete year before the war, 1913, they amounted to no less than 1,086,000*l.*; during 1914, with five war months, the amount was 828,000*l.*; whilst during last year the imports fell to 340,000*l.* The decrease is obviously due to mining conditions in Russia arising out of the war and to interference with the refining industries of France and Germany. Placer mines yielding platinum occur in Northern California and in Southern Oregon; the metal is found there in minute, thin, flaky particles, and is always associated with black sands. It is also obtained from copper-platinum-palladium ore, the product of a mine in Wyoming, and from a gold-platinum-palladium mine in Nevada. Immediately after the commencement of the war the price of platinum rose in the United States, but during the summer of last year there was a sharp decline, which it has been suggested may have been due to the competition of tungsten, molybdenum and nickel-chrome alloys in the electrical industry, and to the substitution of plated platinum ware in jewelry and dental work, in lieu of solid platinum. In the United States the quantity of refined platinum produced from foreign and domestic bullion and matte was 1,100 oz. during 1913 and 2,905 oz. during 1914. During 1912 the Californian output amounted to 603 oz. (troy); for 1913 the combined output of California and Oregon was 483 oz., and during 1914 it reached 570 oz. From 1,053 oz. of crude platinum mined in these two years, 525 oz. of metallic platinum were extracted. A limited additional supply is obtained in the States as a by-product recovered in refining gold and copper bullion from both domestic and foreign ores; this amounted to 500 troy oz. during 1912; 650 oz. in 1913 and 5,869 oz. in 1914. The quantity of refined platinum derived from ores and bullion, entirely foreign, amounted to 37,524 oz. during 1912, 39,154 oz. in 1913, and 25,758 oz. in 1914. Traces of platinum have been found in British Columbia, a few miles from the village of Tulameen. The platinum is associated with chromite, in mines worked for diamonds. Half an ounce has been obtained from a ton of rock in some cases, and in another case a yield of 1 oz. to the ton was obtained. Examined under the microscope, the platinum appears as small rounded pellets, and also as thin sheets, showing a bright metallic lustre; but the supply of chromite is too limited in this locality to render the extraction of platinum economically possible. It is also reported that platinum deposits of considerable extent and of good quality have recently been discovered in Spain. They are situated in the Ronda Mountains about 40 miles north of Gibraltar. These mountains are said to have the same geological structure as the Ural Mountains, but the formations of the Ronda section are much greater than the Russian. More information may be available in the near future. Before the declaration of war, deposits of platinum were discovered in the Rhine Provinces of Germany in sands or gravels some little depth below the surface of the ground, but detailed examination has probably been postponed for the present. More may be heard of these deposits after the termination of the war as they were said to be extensive and appear likely to produce a considerable output. Platinum in small quantities is found in New South Wales and Tasmania; during 1913 the output was 1,275 oz., and in 1914 1,248 oz. In 1913 200 oz. of platinum were obtained from Borneo, Sumatra and elsewhere. The figures for 1914 are not yet available. No platinum has been discovered in this country, so that we are entirely dependent on imports for our supplies. In recent years the imports have been as follow:—

	1910.	1911.	1912.	1913.	1914.
	oz.	oz.	oz.	oz.	oz.
Quantity...	48,162	48,528	42,557	42,640	15,188
	£	£	£	£	£
Value ...	275,500	408,700	383,100	380,700	137,000
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Price per oz. ...	5 14 4	8 8 5	9 0 0	8 18 0	9 6 0

A small quantity of crude platinum is imported from Russia, the amount being 1,778 oz. in 1913 and the average price 7*l.* 4*s.* 1*d.* per oz. For the three previous years the quantities were 4,167 oz., 2,579 oz., and 461 oz., respectively, and the corresponding prices 3*l.* 18*s.* 6*d.*, 7*l.* 1*s.* 5*d.* and 7*l.* 12*s.* 8*d.* per oz. Our imports from Germany were rapidly declining and had practically ceased before the war, only 3 oz. at 7*l.* 6*s.* 8*d.* per oz. being imported in 1914. In 1913 the imports from Germany amounted to 50 oz., valued at 8*l.* 14*s.* 4*d.* per oz., as compared with 1,669 oz., at 9*l.* per oz., imported in 1912. The bulk of our supply of refined metal comes from France and the figures for the last few years are as follow:—

	1910.	1911.	1912.	1913.	1914.
	oz.	oz.	oz.	oz.	oz.
Quantity...	35,149	30,449	33,969	33,149	12,592
	£	£	£	£	£
Value ...	212,260	267,280	311,950	300,550	115,970
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Price per oz. ...	6 0 9	8 15 6	9 3 8	9 1 4	9 4 0

The crude platinum imported from Colombia amounted to 2,296 oz. in 1914 and was valued at 8*l.* 0*s.* 3*d.* per oz., while the imports for 1913, 1912 and 1911 were 3,725 oz., 4,552 oz. and 4,909 oz. respectively, at prices ranging from 7*l.* 15*s.* 8*d.* in 1911 to 7*l.* 19*s.* 5*d.* in 1913. In the previous year, 1910, 2,037 oz. were imported at an average price of 4*l.* 18*s.* 11*d.* per oz. Small quantities usually amounting to only a few hundred ounces annually are imported from the United States, though in 1913, which was an exceptional year, the imports from this country amounted to 3,623 oz. valued at 9*l.* 9*s.* 7*d.* per oz. Our exports, which were steadily declining before the war, went mainly to France and Germany. The quantities exported to France were 878 oz. in 1914, 1,636 oz. in 1913, 2,513 oz. in 1912, 3,358 oz. in 1911, and 7,072 oz. in 1910. The exports to Germany amounted to 54 oz. in 1913, 3,835 oz. in 1912, 2,457 oz. in 1911, and 842 oz. in 1910.

The Ministry of Munitions early in June, in the *Gazette*, scheduled "platinum" as a war material, also any alloy of the metal, with or without the admixture of other metals.

Glass Manufacture in Russia in 1915.—A Congress of Russian glassmakers was held in Moscow last April under the presidency of Prince A. D. Obolenski. According to reports presented to this Congress, Russia had 284 glass works before the war. Of these, 24 certainly were closed during the war, 44 were in territory then occupied by the enemy, and of a large number of works reliable information was not obtainable; about 180 works seemed to be active. The total production had much decreased, especially the manufacture of ordinary bottles; bottles for drugs, and also window glass had been produced in increased quantities.

Swiss Engineering Establishments in 1915.—The annual report of the Verein Schweizerischer Maschinen-Industrieller (we see from the Schweizerische Bauzeitung, of August 5, 1916) is this year less explicit than in previous years, because the Swiss Custom Department would only partly supply the necessary data of exports and imports of raw materials, engines, &c. By the end of 1915 the Association comprised 157 works, with 47,283 employees, against 154 works and 36,123 employees in 1914, and 155 works and 43,181 hands at the end of 1913. The direct effect of the outbreak of the war made itself very badly felt; but by the beginning of 1915 the engineering industry had almost resumed normal conditions, and orders were plentiful; owing to the dearth of some raw materials the situation, however, was not more than satisfactory. The exports and imports of 1915 (figures for 1913 in brackets) were:—Exports: Steam engines, 2,782 (5,595) tons; hydraulic engines and pumps, 3,525 (4,938) tons; internal combustion motors, 5,471 (6,372) tons; dynamos, 5,819 (7,936) tons; machinery for mills, spinning and weaving works also decreased much, whilst automobile exports doubled, 4,795 (2,171) tons. The imports did not vary so strongly, the automobile figures were 259 (1,059) tons, however. The imports of coal were in 1915 nearly up to those for 1913; this holds also for iron and steel, &c. The imports of copper wire and sheet copper went down, those of block copper went up; zinc imports did not change much, lead and nickel decreased. The Association was founded in 1884, and had lost its first and only president, the late Colonel P. E. Huber-Werdmüller having occupied the chair since 1884. The new president is Mr. Carl Sulzer-Schmid (chief of Messrs. Sulzer), and the vice-president Mr. D. Schindler-Huber, director-general of the Maschinenfabrik Oerlikon.

CAPACITY AND ECONOMY OF MULTIPLE EVAPORATORS.*

By E. W. KERR, Baton Rouge, La.

DURING the last few years the author has carried on a large number of investigations of both the capacity and economy of multiple evaporators and vacuum pans. This work has been done in the laboratory on a small apparatus, and in sugar factories on apparatus of commercial size and under regular operating conditions.

Fig. 1. QUADRUPLE EFFECT FOR SUGAR JUICES. TEMPERATURES AND DENSITIES OBTAINED FROM TEST

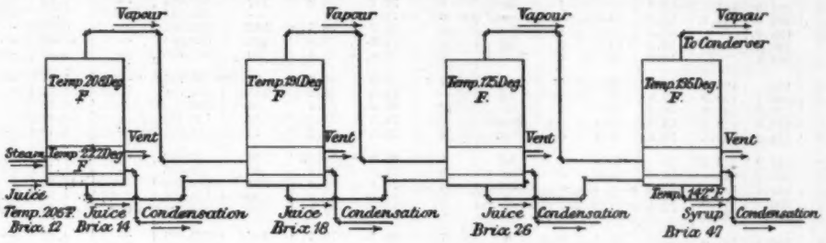


Fig. 2. ONE BODY OF VERTICAL SUBMERGED TUBE EVAPORATOR WITH BELT STEAM DISTRIBUTION (TYPE "A")

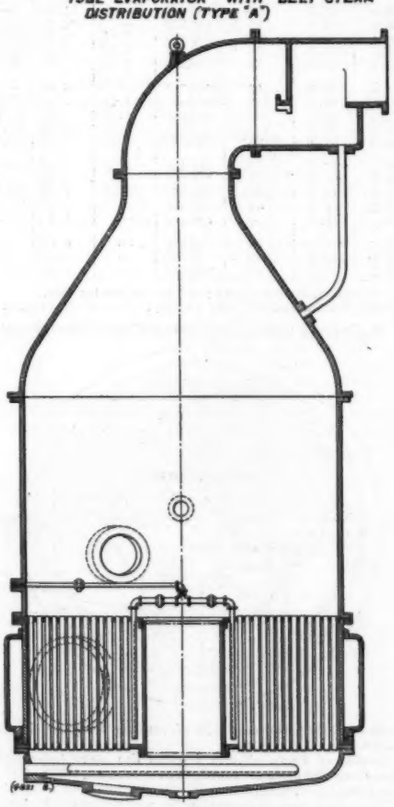
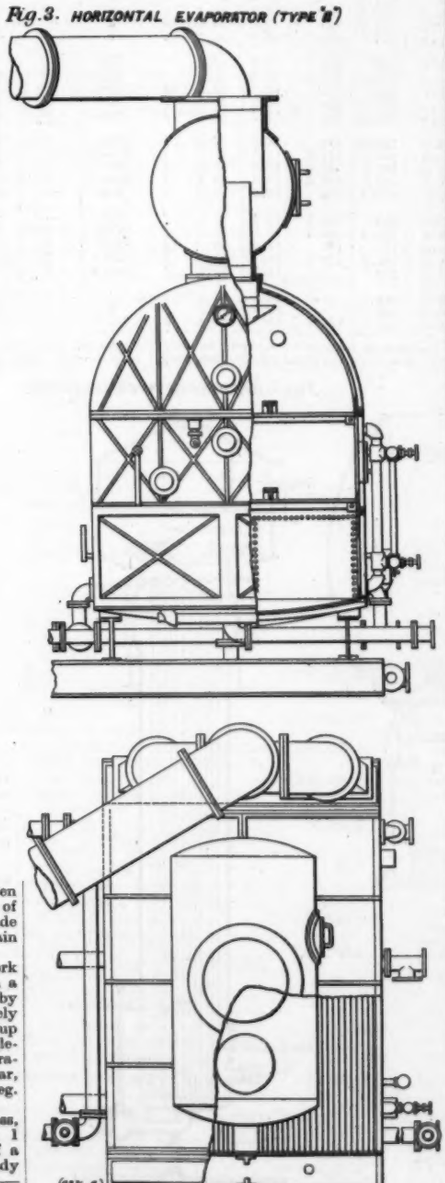


Fig. 3. HORIZONTAL EVAPORATOR (TYPE "B")



The results of much of the laboratory work were given in a former paper before this Society,† and the object of the present paper is to give results of experiments made since the first paper was written, together with certain general observations.

The process of evaporating in sugar factory work consists of two distinct parts: First, the juice with a density of 12 deg. to 18 deg. Brix‡ is concentrated by evaporating off part of its water to approximately 55 deg. Brix in a multiple evaporator. Second, the syrup produced is then taken to a vacuum pan working single-effect, where further water is removed by evaporation under conditions suitable for crystallising the sugar, the final density being in the neighbourhood of 95 deg. Brix.

This paper will consider the first part of the process, namely, the evaporation in multiple effect. Fig. 1 shows diagrammatically the general arrangement of a quadruple effect. Steam is admitted to the first body and is condensed, and the latent heat is transmitted in succession through the heating surface of the four bodies, the boiling temperature in each body being lower than in the preceding body. The thin juice enters the first body, where a portion of the water is removed. The juice then passes in succession to the other bodies, in each of which a portion of the water is evaporated, and leaves the last body at a density which is hand-regulated by means of valves in the liquor lines entering the different bodies. The juice entering each body, except the first, is hotter than the boiling temperature in that body, consequently some heat is delivered by the liquid as well as the steam. Whether heat enters the first body in the liquid or not depends upon the temperature of the entering juice.

Capacity.—The capacity of evaporators depends on two general factors: coefficient of heat transmission and temperature fall.

The factors affecting the coefficient of heat transmission, discussed in the first paper* may be enumerated as:—

1. (a) Steam distribution; (b) Steam velocity.
2. Density of heating steam.
3. Quality of heating steam (whether superheated or not).
4. Presence of air or other incondensable gases in the steam, which may be expressed mathematically by the ratio $P_2 \div P_1$.
5. Presence of condensation on the heating surface.
6. Cleanliness of heating surface (steam side).
7. Material, thickness and molecular structure of tubes.
8. Cleanliness of heating surface (liquid side).
9. Velocity of liquor circulation.

The temperature fall depends on the following factors:—

10. Pressure of steam supplied to first body.
11. Vacuum in last body.
12. Hydrostatic head (height of boiling).
13. Presence of air or other incondensable gases in the steam (see item 4 above).
14. Density of liquid being boiled.
15. Purity of liquid being boiled.

The heat transmitted from steam through a metal wall to a liquid being boiled takes place in three steps: (a) From the steam to the initial surface of the metal; (b) from the initial surface through the metal wall to the cooler surface; (c) from the cooler surface to the liquid being boiled. Items 1 to 6 affect (a); item 7 affects (b); items 8 and 9 affect (c), and items 10 to 15 affect temperature fall.

The paper here considers the effect of design in the various types of evaporators upon these several factors.

Tests of Evaporators in Sugar Factories.—The object of these tests was to gather data regarding the capacity and economy of different types under regular operating conditions. Observations were made of practically all factors which might affect the results. A typical log included observations of the pressure or vacuum in the steam or vapour space of each body; temperature and density of juice entering and leaving; weight of juice entering or leaving; weight of condensed steam from the first body, &c. This form of log was used in tests where data regarding both capacity and economy were sought. It was not possible to weigh the condensed steam from the first body in all cases, so that only capacity data were obtained in many of the tests. In the logs for such tests the weight of the condensed steam from the first body was omitted.

The weight of juice was determined by measuring the volume in factory tanks and then calculating the weight from the densities. The condensation from the first body (steam supplied) was determined by weighing or by a venturi meter, the former in most of the tests.

The instruments for measuring pressures, vacuums, temperatures, &c., were calibrated.

Evaporators Tested.—The evaporators tested included double, triple and quadruple effects, also the following types:—

A. Vertical submerged tube (so-called Standard, Fig. 2).
B. Horizontal steam tube (Fig. 3).
C. Horizontal film (Fig. 4), page 166.
D. Vertical film (Fig. 5).
E. Standard type with special baffle steam distribution, running under vacuum (Fig. 6).
F. Same as E, but with atmospheric pressure in last body, no vacuum apparatus being used.
G. Vertical steam tubes with special means for venting each tube (double tube, Fig. 7).

Types A and B are so familiar that it is not necessary to describe them. It may be well to state, however, that the majority of the sugar house evaporators used in practice belong to one or the other of these two general types.

In type C the horizontal tubes are expanded at one end into a thick tube plate, and at the other are closed except for a small vent which releases the incondensable gases into the vapour space. The water of condensation leaves the tube at the end where the steam enters. Juice is supplied by centrifugal pumps to a distributor above the tubes and falls in a film from one tube to another. The piping is such that the juice may be recirculated over the tubes until the desired concentration in each body is obtained.

In the vertical film type D the juice level is near the bottom of the tubes, the latter being approximately 20 ft. long. A rapid current of steam rising through the tubes sweeps juice along with it. The pressure of the steam on the interior of the tube keeps this juice as a film (often referred to as climbing film) on the tube surface. The juice thus projected upward, on issuing from the tops of the tubes, enters a special separator which separates it from the vapour. The juice and vapour then pass from body to body in the usual manner.

Conditions of Operation.—In order to interpret the results of the tests, it is important to note some of the details of conditions of operation. The most important of these are:—

1. Method of removing condensation.
2. Method of venting the incondensable gases.
3. Condition of the heating surface.

Referring to Fig. 1, the removal of condensation from the steam compartments may be effected by:—

(a) Pumps from each body.
(b) Siphoning the condensation from body to body, a pump being used to remove it from the last body.

* Paper read before the American Society of Mechanical Engineers.

† Tests upon the Transmission of Heat in Vacuum Evaporators, Trans. Am.Soc.M.E., vol. 35, page 731.

‡ The Brix saccharometer or hydrometer indicates directly the percentage of sugar dissolved.

* Tests upon the Transmission of Heat in Vacuum Evaporators, Trans. Am.Soc.M.E., vol. 35, page 731.

TABLE I.—PRINCIPAL DATA FROM TESTS ON SUGAR HOUSE EVAPORATORS.

No.	Duration, hr.	Type.	Number of Bodies.	Rated Capacity, Gal. per 24 hr., 75 per Cent. Evaporation.	Length of Tubes, ft.	Diam. of Tubes, in.	Heating Surface, Each Body, sq. ft.	Steam Pressure 1st Body, lb. Abs.	Steam Pressure Last Body, in. Abs.	Temperature, Deg. Fahr.		Density Degrees Brix at 17.5 deg. C.		Method of Removing Condensation.*	Method of Venting.*	Number of Days Since Cleaned.	Per Cent. Evaporation.		Juice Treated per 24 hr. Equiv. to 75 per Cent. Evap., per Cent. of Rated.	Water Evaporated, lb.	Water Evaporated per lb. of Steam Supplied, lb.	Water Evaporated per sq. ft. Heating Surface per hr., lb.	Thermal Efficiency, per Cent.
										Juice Entering.	Juice Leaving.	Juice Entering.	Juice Leaving.				By Weight.	By Volume.					
1	7.13	A	4	290,000	4.5	2	4504.8	16.3	1.8	183.5	101	13.7	50.2	*f*	*be*	6	72.7	76.6	137	587,914	—	5.44	—
2	6.00	A	3	270,000	4	2	3740	14.6	3.6	185.9	134.2	15.2	55.5	—	—	3	72.6	77	—	350,584	—	5.19	—
3	6.66	A	3	290,000	4	2	3983	15.3	3.2	188.6	—	13.2	52.2	*e*	None	3	74.7	78.6	102	505,304	—	6.35	—
4	12.0	A	3	185,000	4	2	2579	15.6	3.4	198.4	—	15.4	61.1	*e*	*bd*	0	74.7	79.4	138	933,684	—	10.38	—
5	5.75	A	3	280,000	4	2	—	16.7	4.9	183.8	—	13.6	51	*e*	Note 1	0	73.4	77.4	83	327,466	—	4.96	—
6	4.33	A	3	210,000	4	2	2855	14.7	3.5	194	124.5	13.3	58.2	*e*	None	7	77.2	81.3	87	195,763	—	5.27	—
7	4.92	A	2	125,000	4	2	1901	14.9	5.2	206.7	128.9	15.9	56	*e*	*ad*	—	71.6	76.1	145	104,775	2.09	5.67	—
8	3.5	A	2	120,000	4	2	1808	13.6	5.1	172.7	137.1	16.9	42.4	*e*	*ae*	12	60.3	64.4	86	88,255	—	6.95	—
9	6.0	A	2	130,000	4	2	2137.6	14.4	4.1	176.8	123.2	13.6	52.4	*e*	None	0	74.1	78.1	63	124,474	—	4.85	—
10	4.5	A	2	130,000	4	2	2137.6	14.5	3.8	174.3	123.1	13.2	51.3	*e*	None	6	74.3	78.2	42	54,504	—	3.19	—
11	6.0	A	2	100,000	4	2	1585.6	14.9	6.2	185.2	143.4	15	48.3	*e*	*bd*	3	68.9	73.01	64	95,857	—	5.04	—
12	6.16	A	2	100,000	4	2	1585.5	14.7	6.9	188.0	144	14.1	49.4	*e*	*be*	0	71.5	75.5	90	141,888	—	7.26	—
13	5.0	A	2	125,000	4	2	2042	14.7	5.0	188.6	140	13.3	54.2	*e*	*bd*	3	75.4	79.4	151	239,478	—	11.72	—
14	4.0	B	4	145,000	9½	⅝	2000	22.9	3.1	200	119.8	18.1	55.9	Note 2	*d*	6	67.6	72.5	109	155,198	3.52	4.85	85.06
15	4.0	B	4	145,000	9½	⅝	2000	21.4	3.8	199.7	129.2	17.5	62.9	Note 2	*d*	3½	72.2	77.2	174	248,701	3.7	7.77	89.05
16	6.0	B	4	145,000	9½	⅝	2000	23.4	4.0	200.5	127.3	16.0	47.2	Note 2	*d*	7	66.1	70.3	107	225,586	—	4.69	—
17	6.0	B	4	250,000	13	⅝	3432	18.7	3.7	181.0	—	13.0	57.5	*e*	*c*	0	77.5	81.4	86	314,062	3.4	5.08	90.48
18	4.5	B	4	250,000	13	⅝	3432	17.4	5.0	196.5	140	13.0	59.3	*e*	*c*	0	78.1	82.1	116	319,833	—	5.18	—
19	6	B	3	125,000	11	⅝	1560	15.5	7.5	186.2	135	13.2	54.3	*e*	*c*	—	75.7	79.7	62	113,716	2.86	4.05	100.4
20	5.33	B	3	200,000	13	1¼	2849	20.9	3.3	195	130	10.6	58.3	*e*	*c*	1	83.5	85.1	191	502,311	—	11.03	—
21	6.00	B	3	80,000	10	1¼	654.3	20.1	3.3	195	131	11.7	58.5	*e*	None	1	79.9	83.1	290	130,669	—	11.09	—
22	5.00	B	2	100,000	13	1¼	1633.6	15.5	4.6	172.7	137.1	16.2	53.7	*e*	None	10	69.8	74.3	97.9	116,729	—	7.1	—
23	6.00	C	4	400,000	7½	4½	2570	19.1	5.9	194	141	12.7	53.2	*g*	Spec.	0	76.1	79.9	94	556,923	3.71	9.02	96.9
24	6.00	C	4	400,000	7½	4½	2570	17.7	6.5	191.8	144	13.1	58.7	*g*	Spec.	0	77.7	81.7	94	553,877	3.95	8.98	97.5
25	6.06	C	4	400,000	7½	4½	2410	17.9	4.6	188.8	131	12.7	65.4	*g*	Spec.	0	80.6	84.6	76	450,293	3.69	7.71	97.5
26	6	C	4	275,000	7½	3	1940	9.4	4.0	199.3	132	14.9	52.3	*f*	Spec.	0	71.6	75.8	62	264,780	—	5.68	—
27	7.13	D	4	400,000	—	—	4000	17.9	5.2	205.0	141.8	11.6	47.3	*f*	Note 3	3	75.5	78.9	138	837,836	4.21	7.34	97.2
28	6·03	D	4	400,000	—	—	4000	17.9	4·9	207.7	136.9	12.6	46.2	*f*	Note 3	2	72.7	76.7	124	748,958	4.24	7.76	94.8
29	6	D	4	400,000	—	—	4000	18.1	5.2	208.8	132.6	12.8	45.4	*f*	Note 3	0	71.8	75.5	131	790,172	4.28	8.23	93.3
30	4	D	3	200,000	23	—	2112	14.8	2.3	212.2	125	16.5	46.2	*f*	None	—	64.3	68.5	93	191,585	2.91	7.77	86.5
31	5	D	3	200,000	23	—	2112	13.6	2.3	213	122.1	15.2	50.1	*f*	None	—	69.7	73.9	95	247,400	3.09	7.81	90.6
32	5.87	D	3	145,000	26	2	—	18	3.6	175.4	124.5	16.5	54.3	*f*	None	1	69.7	74.3	85	173,133	—	6.26	—
33	6	E	3	220,000	4	2	3054	14.6	4.6	171	136	14.9	58	*f*	Fig. 6	1	75.4	78.8	105	338,859	2.49	6.27	97.4
34	5.39	E	3	—	4	2	2683	11.06	5.0	184.6	129.2	15	51	*f*	Note 4	2	70.6	74.8	—	190,517	—	4.4	—
35	4	E	3	—	4	2	2683	6.07	3.2	179	—	14.7	50.8	*f*	Note 4	7	73	75.2	—	156,176	—	5.3	—
36	6	F	2	—	4	2	1003.1	24	30.0	204.4	—	15.2	45.3	*e*	*a*	0	66.5	70.5	—	73,502	—	6.11	—
37	6	F	2	—	4	2	1007.0	24	30.0	192.6	—	15.9	46.2	*e*	*a*	1.5	65.6	69.8	—	77,161	—	6.43	—
38	5.69	G	4	290,000	4	2	1529	15.4	5.8	188.1	147.4	15	64.2	*e*	Fig. 7	3	76.7	81.2	51	206,917	—	5.95	—

* *a*—Through shell at side; *b*—through top tube sheet; *c*—direct to condenser; *d*—body to body; *e*—pumps, each body; *f*—siphon, body to body; *g*—barometric leg pipe.
Note 1.—Vented through 12 1/16-in. holes direct to vapour space. Note 2.—Centrifugal pumps, each body. Note 3.—2-in. vents at side, bottom and top, body to body. Note 4.—See Fig. 6.

Fig. 4. ONE BODY OF TYPE "C" EVAPORATOR.

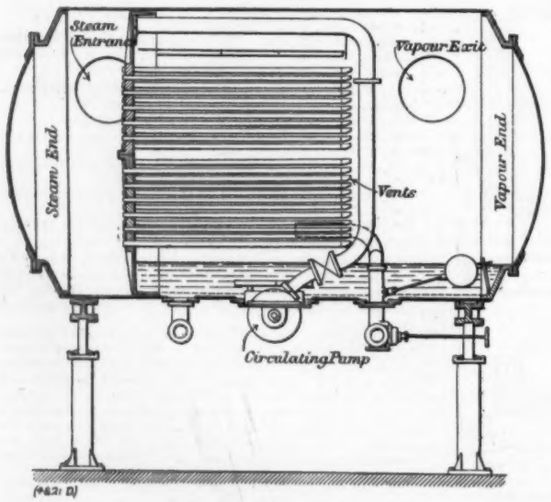


Fig. 5. ONE BODY OF TYPE "D" EVAPORATOR.

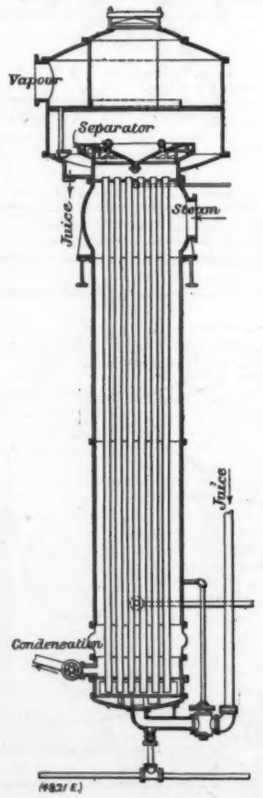
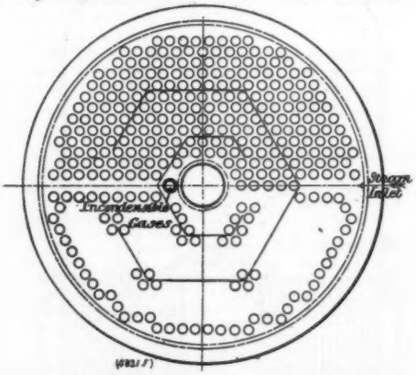


Fig. 6 STEAM DISTRIBUTION (TYPES "E" AND "F" EVAPORATORS)



(c) Barometric leg pipe; this method can be used only in case the evaporator is high enough to give a column of water sufficient to balance the vacuum in the space being drained.

The venting of incondensable gases may be effected by:—

(a) Small pipes tapped through the shell just under the top tube sheet.

(b) Small pipes tapped into the top tube sheet and located near the downtake. Usually two or four of these tubes are used, which are connected together inside of the vapour space with a single pipe brought through the shell and a valve placed on the outside for control.

(c) In horizontal evaporators the steam chest opposite the steam entrance is vented.

(d) Special methods depending on the type of evaporator.

In all of the above the vented gases may be taken direct to the condenser or to the next body, though so far as heat transmission is concerned it is doubtless better to vent direct to the condenser. Usually valves are placed in vent lines in order that control may be exercised. In some cases the venting is continuous and in other cases intermittent, depending upon the ideas of the operator. In types C and G special means of venting are used which have been explained above. Data regarding the methods of venting are given in the tables.

Results of Tests.—Table 1 gives the more important data from the tests on multiple evaporators. Fig. 8 is a graphical log of a typical test.

The percentage evaporation by weight was calculated by means of the formula $X = \frac{(B - b)}{B} \times 100$, in which B is the Brix of the juice leaving, *b* the Brix of the juice entering, X the per cent. water evaporated in terms of the weight of the juice. In determining the percentage evaporation by volume, the formula $X = 100 - 100\ (gb/BG)$ was used, *g* being the specific gravity of the juice entering, and G the specific gravity of the juice leaving. In most cases the volume of the juice leaving was measured in factory tanks, the weight of juice entering and the weight of water evaporated being calculated by the use of the first formula above.

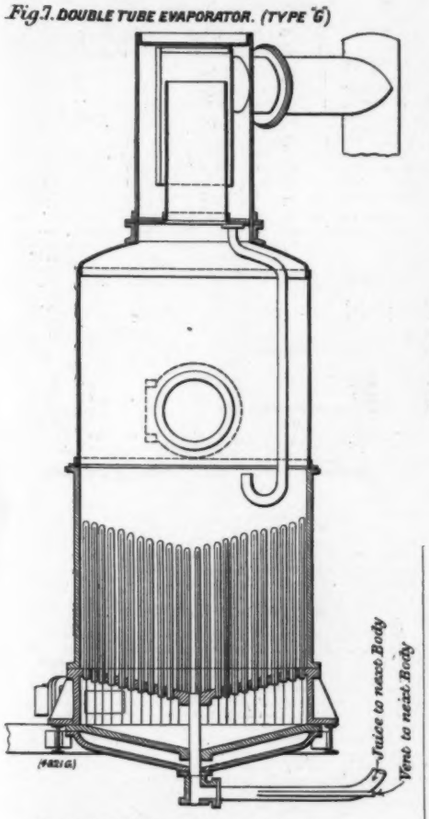
It is customary to make evaporator guarantees on a basis of 75 per cent. evaporation by volume. As the initial and final densities of the juice are seldom such as to give exactly 75 per cent. evaporation, it is necessary to determine the "equivalent volume of juice in gallons per 24 hours" by calculation. There seems to be no standard unit for rating evaporators. Sometimes an evaporator is guaranteed to handle a stated number of gallons of juice per 24 hours with 75 per cent. evaporation, nothing being stated as to the temperature of the juice; in other cases the temperature of the juice is specified. Probably the best standard rating would be "equivalent gallons of juice handled per 24 hours with 75 per cent. evaporation." Primarily a multiple evaporator is supposed to evaporate and not heat; actually, however

the juice may enter the first body at a temperature lower or higher than that of boiling.

The following example shows the method used in calculating "equivalent juice treated with 75 per cent. evaporation" (see Table I).

Boiling temperature, first body, deg. Fahr.	194.07
Temperature juice entering first body	172.71
Temperature rise	21.36
Specific heat juice entering ...	0.889
British thermal units per hour, first body, for heating 41,832 × 21.36 × 0.889	794,349
Latent heat at 194.07 deg. ...	981.35
Equivalent evaporation, lb. $\frac{794,349}{981.35}$ = ...	809.4
Total per 24 hours, lb.	19,425.6
Actually evaporated per 24 hours, lb.	605,174.4
Equivalent, had all heat been expended in evaporating, lb. ...	624,600.0
Equivalent gallons at 194 deg. ...	73,456.3

Fig. 7. DOUBLE TUBE EVAPORATOR. (TYPE "G")



Equivalent juice at 75 per cent. evaporation, 73,456 ÷ 0.75 =	97,941.0
Rated capacity, gallons per 24 hours	100,000
Per cent. rated capacity actually developed	97.9

The term thermal efficiency (Table I., last column) is used to indicate the heat efficiency of the evaporator as a whole. It may be determined by dividing the actual weight of water evaporated per pound of steam supplied by the theoretical weight of water that would be evaporated per pound of steam supplied were there no heat losses.

In order to illustrate the method used in calculating efficiency, the following example is worked out for a double effect. The general data used in working out the heat balance on which the efficiency determination is based are :—

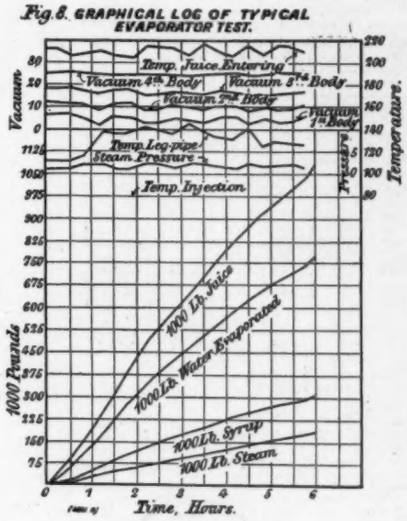
Total juice fed, lb.	94,706.9
Total steam condensed, lb. ...	36,302.0
Brix of juice entering	12.2
Specific heat*	0.919
Temperature juice entering ...	186.06
Calandria, first body—	
Steam pressure, lb. abs ...	15.46
Steam temperature	214.56
Total heat above 32 deg. ...	1,151.33
Juice side, first body—	
Vapour pressure, in merc. abs...	25.65
Vapour temperature	204
Total heat above 32 deg. ...	1,147.3
Latent heat above 32 deg. ...	975.18
Juice side, second body—	
Vapour pressure, in merc. abs ...	7.94
Latent heat above 32 deg. ...	1,006.2

The heat balance was calculated as follows :—

First Body.

British thermal units entering in steam, 36,302 × 1,151.33 = ...	41,795,581.6
British thermal units entering in juice, 94,706.9 × 154.06 × 0.919 = ...	408,710.8
Total	55,204,292.4
British thermal units leaving in condensation, 36,302 × 182.56 =	6,627,293.1
British thermal units in juice in body, 94,706.9 × 0.919 × 172.32 = ...	14,997,981.6
Sum	21,675,274.7
British thermal units leaving in vapours (55,204,292.4 — 21,625,274.7) = ...	33,579,017.7
Vapour leaving, lb., 33,579,017 ÷ 975.18 = ...	34,433.7

Fig. 8. GRAPHICAL LOG OF TYPICAL EVAPORATOR TEST.



Juice to second body, lb., 94,706.9 — 34,433.7 = ...	60,273.2
Brix of juice entering second body, $\frac{94,706.9 \times 12.2}{60,273.2}$ = ...	19.17
Specific heat at 19.17 Brix ...	0.874

Second Body.

British thermal units entering in vapours, 34,433.7 × 1,147.4 =	39,510,260.4
British thermal units entering in juice, 60,273.2 × 172.32 × 0.874 = ...	9,077,606.8
Total	48,587,867.2
British thermal units leaving in condensation, 34,433.7 × 172.32 = ...	5,933,615.2
British thermal units in juice in body, 60,273.2 × 120 × 0.874 =	6,321,453.2
British thermal units leaving in vapours...	36,332,798.8
Vapours leaving, lb., 36,332,798.8 ÷ 1,006.2 = ...	36,108.9
Juice leaving second body, lb. ...	24,164.3
Brix leaving second body, $\frac{60,273.2 \times 19.17}{241,164.3}$ = ...	47.8
Total water evaporated, lb., theoretical, 34,433.8 ÷ 36,108.9 = ...	70,542.7
Per cent. of total evaporation, in first body	48.8
Per cent. of total evaporation, in second body	51.2
Total water evaporated (theoretical) per lb. of steam 70,542.6 ÷ 36,302 = ...	1.9432
Total water evaporated (actual) per lb. of steam	1.9108
Thermal efficiency $\frac{1.9108}{1.9432}$ 100 =	98.33

HEAT BALANCE OF DOUBLE EFFECT.

Heat entering in steam, British thermal units	41,795,581.6
Heat entering in juice	13,408,710.8
Total	55,204,292.4
Heat leaving in condensation, first body	6,627,293.1
Heat leaving in condensation, second body	5,933,615.2
Heat leaving in vapours, second body	36,332,798.8
Heat leaving in syrup, second body	6,321,453.2
Total	55,215,164.3

The coefficient of heat transmission, the British thermal units transmitted per square foot of heating surface per hour per degree difference in temperature, is obtained for each body by dividing the heat in British thermal units transmitted during the test by the number of hours, by the number of square feet of heating surface and by the apparent temperature fall in that body. The coefficients of heat transmission obtained in the tests are given in the paper for each body, also the average for all bodies. As the apparent temperature fall was used, the coefficients are termed apparent.

(To be continued.)

* The values for specific heat of sugar solutions with varying density were taken from Kopp's tables.

COLONIAL AND FOREIGN ENGINEERING PROJECTS.

WE give below a few data on several colonial and foreign engineering projects taken from the *Board of Trade Journal*. Further information on these projects can be obtained from the Commercial Intelligence Branch, 73, Basinghall-street, London, E.C.

New Zealand.—H.M. Trade Commissioner in New Zealand calls attention to a notice published in the official *New Zealand Gazette* to the effect that it has been decided, on a poll of the ratepayers, to borrow the sum of 24,000*l.*, to be devoted to the extension of the water supply and sewerage systems at Palmerston North. The Borough Council of Palmerston North will also raise a loan of 4,000*l.* for the purpose of constructing and fitting up a tepid swimming bath.

South Africa.—H.M. Trade Commissioner in South Africa has forwarded a copy of the final Estimates of Expenditure of the South African Railways and Harbours for the year ending March 31, 1917 :—Railways : The total estimated expenditure on railways is put at 13,867,055*l.* The following expenses are assigned under the heading "Maintenance of Permanent Way" : Sleepers, 92,447*l.* ; rails, 60,599*l.* ; other material, 24,803*l.* ; bridges, 34,391*l.* ; crossings, overhead bridges, fences, &c., 14,175*l.* ; signals, 27,624*l.* ; telegraphs and telephones, 55,099*l.* ; and water supply, 23,436*l.* As regards material for the maintenance of rolling stock, 283,637*l.* is allotted in connection with locomotives, 92,593*l.* for coaching stock, and 213,176*l.* for goods stock. 39,862*l.* is assigned for expenditure on lubricating supplies, 20,638*l.* for running stores for locomotives and vehicles, and 109,439*l.* for tarpaulins. Harbours : The total estimated expenditure on harbours is put at 1,199,288*l.* The following sums appear under the heading "Maintenance" : Dredging, 43,864*l.* ; jetties, wharves, and quays, 14,921*l.* ; breakwaters and sea walls, 5,720 ; buildings, &c., 20,133*l.* A copy of the estimates of expenditure for the year ending March 11, 1917, of the Province of Natal, has also been received from H.M. Trade Commissioner in South Africa. The amount assigned in favour of hospital and charitable institutions is 41,753*l.*, including 6,600*l.* for provisions, 2,500*l.* for clothing and household requisites, and 2,700*l.* for medicines and medical and surgical equipment. Under the heading "Roads and Local Works" 92,050 is assigned for road maintenance and repair, 34,500*l.* for deviations and permanent improvements, and 6,600*l.* for new road construction. The estimate of expenditure on school and hospital buildings is put at 73,315*l.*, and that for bridges at 30,330*l.* H.M. Trade Commissioner in South Africa has also forwarded a copy of a recent report by the Finance Committee of the Johannesburg Municipal Council, from which it appears that the council contemplates an extraordinary expenditure of about 100,000*l.* per annum on certain remunerative and unremunerative undertakings until such time as they have reached completion. The undertakings classed as "remunerative" are electric power supply, tramways, water supply, abattoir, live-stock market, and produce market; the "unremunerative works" are the sewerage system, roads and drainage, and the Art Gallery.

Brazil.—The *Diario Official*, Rio de Janeiro, publishes a Decree (No. 12,114) approving the plans and estimates for the construction and equipment of modern railway repair shops at Passa Quatro, State of Minas Geraes, for the Sul-Mineira railway system. The estimated cost of the works is 1,339,917 milreis (about 71,000*l.* at current rate of exchange). The undertaking must be commenced within a period of three months from the date of the Decree (June 28) and completed within a period of two years.

Uruguay.—The *Diario Oficial*, Montevideo, publishes a Law authorising the "Junta Económico-Administrativa" of Montevideo to issue bonds to the value of 1,000,000 pesos (about 217,000*l.* at current rate of exchange), bearing interest at the rate of 6 per cent. per annum, for the carrying out of sewerage works at that city. The works will be effected by contract with private firms, after public calls for tenders, or by the municipal authorities themselves. The Law provides, however, that works may only be undertaken by administration when it is considered possible to execute them at a cost less than would have resulted from a public call for tenders.

AMERICAN COAL-MINING.—The production of bituminous coal in the United States in the first half of this year was the largest ever recorded in any six months, coming out as it did at 261,000,000 tons, or 35 per cent. more than the output for the first half of 1915.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACT OF 1907.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the Communicators are given in italics.

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The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

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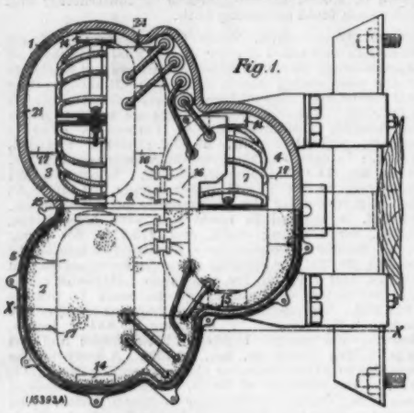
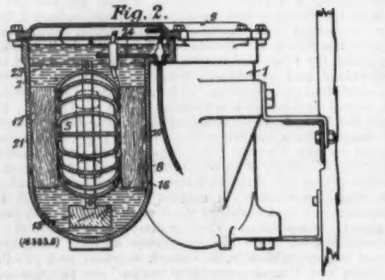
ELECTRICAL APPARATUS.

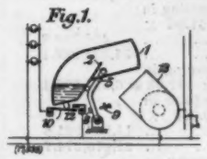
16,393/15. Western Electric Company, Limited, London. (*Western Electric Company, New York, U.S.A.*). **Loading Coils.** (3 *Figs.*) November 20, 1915.—This invention relates to loading coils for telephone systems, and more particularly to loading coils having one or more non-magnetic gaps in the cores thereof, as described in Specification No. 12,434 of 1915. According to this invention, the casing is formed to present a contour coinciding approximately with a surface of uniform force due to magnetic leakage from the coil when in use. A casing 1, having three compartments 2, 3 and 4, is provided for two side circuit loading coils 5 and 6, and one phantom circuit loading coil 7, respectively. The coils shown are of a type having a toroidal core with two diametrically opposite air-gaps maintained by gap spacers. Spacing blocks of wood are provided for holding the coils centrally within their compartments. One of the blocks 13 rests in the bottom of the coil compartment. Four other

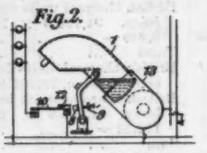




blocks 14, 15, 16 and 17 are arranged around the sides of the coil. These blocks are of such size and shape that they suspend the loading coils further away from the bottom and top walls of the compartments than from the side walls. The greatest distance of the coils from the walls 20 and 21 is likewise greater than the distance from the side walls. The greatest distance between the coil and the casing is opposite that part of the coil which includes the air gaps, and the least is opposite that part of the coil which is furthest away from the air-gaps. After the coils have been placed in their compartments, the casing is filled with an insulating compound up to the line 23. An insulating partition plate 24 is then placed over the coils, this partition resting upon a ledge of the casing. The terminal wires of the coils are then brought through bushings piercing this partition, and the appropriate connections made to the outside of the casing through bushings. (*Accepted May* 31, 1916.)

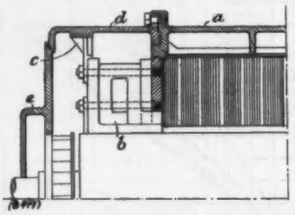
17,535/15. Allmanna Svenska Elektriska Aktiebolaget, Wasteras, Sweden. Electrical Switches. (4 *Figs.*) January 9, 1915.—This invention relates to time lag switches of the type in which the retardation is effected by a liquid flowing slowly from one portion of a receptacle to another portion thereof. In carrying out the invention, a receptacle containing the liquid is freely suspended in a pivotally mounted frame in such manner that when the receptacle is moved by means of an electromagnet to working position, while the liquid at the same time moves from one part of the receptacle to another part thereof, the centre of gravity common to the receptacle and the liquid lies between the vertical planes through the pivots of the receptacle and of the frame, while, on de-energisation of the electromagnet after the liquid has flowed back to the first-named part of the receptacle, the point of gravity is moved past the vertical plane through the pivot of the frame. 1 is a closed angular receptacle provided with a partition wall 2. The partition wall is provided with a small aperture. The lower portion of the receptacle is, in the position shown in Fig. 1, partially filled with a liquid. The receptacle 1 is pivotally suspended in a frame 5 pivotally mounted in bearings secured to a bed-plate. 13 is an electromagnet, the pole-shoes of which are so arranged that the receptacle 1 may move between them. When the circuit of the electromagnet 13 is closed, the receptacle 1 acts as an armature and is attracted between the pole-shoes of the electromagnet until the frame 5 strikes the stop 9. The receptacle occupies now the position shown in Fig. 2. As soon as the circuit of the electromagnet is broken, the receptacle swings back, because its centre of gravity lies to the left of the vertical plane through its pivots. The





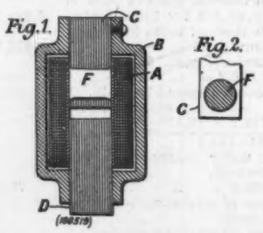
frame 5, however, remains still in contact with the stop 9, since the centre of gravity common to the receptacle and the frame lies to the right of the vertical plane through the frame bearings. The frame remains in this position until there has passed through the aperture of the partition wall 2 a quantity of the liquid sufficient to move the common centre of gravity to the left of the bearings. The frame, together with the receptacle 1, is then moved back to the position shown in Fig. 1 in which contact between the members 10 and 12 is broken. (*Sealed.*)

8,417/15. Maschinenfabrik Oerlikon, Oerlikon, Switzerland. Dynamo-Electrical Machines. (3 *Figs.*) June 30, 1914.—According to this invention, the casing for the stators of dynamo-electrical machines is constructed in such way that the portion of the casing which projects beyond the active iron of the stator is made in the form of a detachable ring, which, on removal, allows free access to the coil heads without necessitating the removal of the entire casing, while at the same time providing a secure support for the radial bracings of the coil heads. *a* is the actual casing, *b* are the coil heads projecting beyond the casing and secured by the braces *c* to the extension *d* of the casing, which is made as a detachable ring or annular segment. The facing *e* is of the ordinary end-facing pattern. The detachable



casing ring *d* is firmly secured to the casing by dovetailing and numerous bolts. Up to the time the winding is completed, this ring remains detached from the casing, and thus allows ready accessibility to the winding from all sides. This is equally the case during inspection and repairs, for which purpose the casing ring can be easily removed after taking down the braces *c*. On the other hand, in the finished machine the ring forms a complete aggregation with the casing, and forms a secure support for the radial bracing of the coil heads. In case it is desired to subdivide the ring into segments, to facilitate assembling, this subdivision is left to the discretion of the maker, as is also the method of connecting the ring with the casing, which may project over the active iron in the form of a wider or narrower rim or flange. (*Accepted June* 7, 1916.)

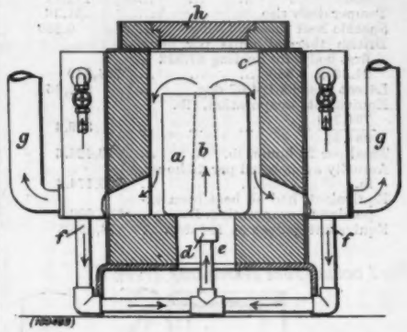
100,519. Waygood-Otis, Limited, London (*Otis Elevator Company, New York, U.S.A.*). **Alternating Current Electro-Magnets.** (6 *Figs.*) March 7, 1916.—In alternating-current electro-magnets of the type disclosed in Specification 16,374 of 1911, the core carries secondary conductors, in which is induced a current different in phase from that energising the primary coil. The present invention consists in making the secondary conductor, or conductors, in the form of a bar or rod of magnetic material disposed transversely across and through the laminations of the core. The bar is arranged adjacent to the pole face and the secondary current then circulates within the mass of this transverse bar. A is the primary coil, enclosed in a casing B. The laminated core is formed in two parts C and D.



The part C is clamped in the casing and the part D is movable in the coil and constitutes the armature. In the form shown, a straight bar or cylinder F of magnetic material is secured transversely across the core laminations, and passes through them as illustrated. This bar may serve as a rivet to hold the laminations together. When the single-phase alternating current is supplied to the coil A, a current of different phase is induced in the bar F, and circulates therein in a direction at right angles to the core laminations. Under these conditions the current energising the magnet never falls to zero, and by reason of the magnetic symmetry, a constant resultant pull in a straight line coincident with the axis of symmetry of the magnet is exerted upon the armature D to hold it firmly attracted, without chattering or vibration. (*Accepted June* 7, 1916.)

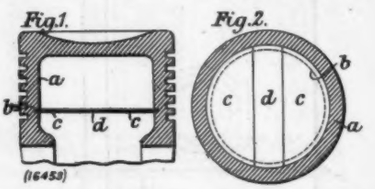
GAS-ENGINES, PRODUCERS, HOLDERS, &c.

100,499. South Metropolitan Gas Company, and D. Chandler, London. Gas-Heated Crucible Furnaces. (1 *Fig.*) January 5, 1916.—To facilitate the melting of substances in annular or vertical flue crucibles by means of gas, such, for instance, as brass, lead, tin, &c., the invention consists in so arranging the furnace that the heat from the burner passes up through a vertical passage within the crucible and returns between the outer walls of the crucible and the walls of the furnace, thus providing for the heating of the crucible in the most efficient manner both within and without. The drawing shows, in sectional elevation, a crucible furnace arranged in accordance with the present invention. *a* is the crucible of annular form with a central passage *b* therein. *c* is the furnace provided with solid walls of refractory material. *d* is the burner



placed within an orifice *e* in the bottom of the furnace, over which orifice the crucible *a* stands. The burner *d* is supplied with gas and air by pipes *f*, *f*, and the flame from the burner passes through the passage *b* of the crucible, turns outwards over the top of the crucible, and finds an exit by the flues *g*, *g*, after travelling between the outside of the crucible and the walls of the furnace. A cover *h* is provided for the furnace, and a cover may also be provided for the crucible if desired, although none is shown in the drawing. (*Accepted June* 7, 1916.)

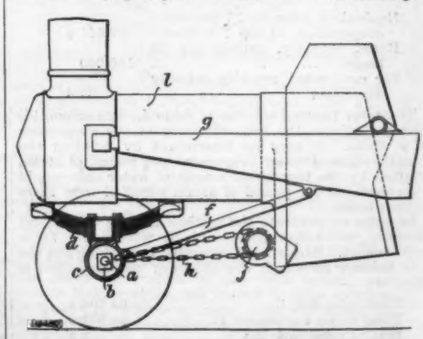
16,453/15. Sir W. G. Armstrong, Whitworth and Company, Limited, and L. J. Le Mesurier, Newcastle-upon-Tyne. Internal-Combustion Engines. (2 *Figs.*) November 22, 1915.—This invention relates to guards for preventing the splashing of oil upon the pistons of internal-combustion engines, and in the method of securing the guards to the pistons. Accord-



ing to this invention, the guard is a diaphragm consisting of one or more thin plates which are inserted into a groove formed in the piston. On the inside wall *a* of a piston is a groove *b* into which a diaphragm consisting of two segmental plates *c*, *c*, and a third plate *d* is inserted. The two plates *c*, *c* are inserted into the groove *b*, and the plate *d* is sprung into the groove *b*, locking the plates *c*, *c*. (*Accepted June* 14, 1916.)

MOTOR ROAD VEHICLES.

16,459/15. Clayton and Shuttleworth, Limited, P. W. Robson, and F. J. Bretherton, Lincoln. Motor Road Vehicles. (2 *Figs.*) November 22, 1915.—The present invention relates to motor vehicle fore-carriages of the type in which, for steering, the front axle as a whole moves about a central pivot, and relates more particularly to resiliently mounted fore-carriages of this type in which a universal joint is provided between the axle and the vehicle chassis. The present invention consists in a construction in which the fore part of the vehicle chassis is supported on a spring or other resilient member which is carried upon one element of a non-resilient universal joint, this element being also connected to the chassis by hinged radius rods, while the other element of the joint is mounted directly upon the front axle. In carrying the present invention into effect according to



one form, and as applied to a steam wagon, the front axle *a* is provided at its centre with a spherical portion *b*. Around the spherical portion *b* a socket *c* is fitted, this socket carrying a pad for the spring *d* and a lug for its connection by radius rods *f* to the side members *g* of the chassis. It will be understood that any suitable form of universal joint may be employed in place of the ball-and-socket joint illustrated. The axle *a* is rotated about its steering centre by chains or the like *h* wrapped round the drum *j*, which may be operated by any suitable means. In order to allow for the slight fore-and-aft movement of the axle relatively to the chassis due to the action of the radius rods *f*, the ends of the spring *d* may be conveniently allowed to slide in boxes attached to the underside of the boiler *l*. (*Accepted June* 14, 1916.)